National Park Service
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Natural Resource Program Center

Paleontological Resource Inventory and Monitoring *Southeast Alaska Network*

Natural Resource Technical Report NPS/NRPC/NRTR—2008/108

ON THE COVER
Historic photos of the Fossil Forest near Muir Glacier, Glacier Bay National Park, taken during the late 1800s (John Muir's Expedition).

Paleontological Resource Inventory and Monitoring
Southeast Alaska Network

Natural Resource Technical Report NPS/NRPC/NRTR—2008/108

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NOTE:
This report provides baseline paleontological resource data to National Park Service administration and resource management staff. The report contains information regarding the location of non-renewable paleontological resources within NPS units.
It is *not* intended for distribution to the general public.

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Natural Resource Program Center
Fort Collins, Colorado

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Abstract

Paleontological resources (fossils) are any remains of past life preserved in a geologic context. Paleontological resources are non-renewable resources found in more than 190 National Park Service units. Despite the abundance and diversity of these resources throughout the NPS, until recently few parks have adequate baseline paleontological resource data.

The NPS National Inventory and Monitoring Program and the NPS Geologic Resources Division have developed various strategies to provide parks with the baseline paleontological resource data necessary for greater understanding and appropriate management of these resources. This report presents a paleontological resource summary for the parks of the Southeast Alaska Network. The summary was compiled through extensive literature reviews and interviews with park staff and professional geologists and paleontologists. Preliminary paleontological resource management recommendations are also included for each park. Similar summaries have already been prepared for 19 other NPS Inventory and Monitoring Networks. The National Inventory and Monitoring Program provided funding to complete these paleontological resource summaries for each of the remaining networks.

The paleontological resources known from the parks of the Southeast Alaska Network are primarily limited to Paleozoic and middle to late Cenozoic fauna and flora. Glacier Bay National Park and Preserve (GLBA) contains some interesting and important Silurian fossil occurrences which have been the focus of recent and ongoing research. Additionally the Fossil Forest described by John Muir provides an important paleoclimatic and taphonomic resource for current and future research. Fossils are not currently known from Klondike Gold Rush National Historical Park (KLGO) and Sitka National Historical Site (SITK).

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Introduction

Paleontological resources, or fossils, are any remains of past life preserved in geologic context. There are two main types of fossils: body fossils and trace fossils. Body fossils are the physical remains of an actual organism (shells, bones, teeth, plant leaves, etc.) while trace fossils (burrows, coprolites, footprints, trackways, etc.) preserve evidence of an organism's activity or behavior. Fossils are non-renewable natural resources that possess great scientific, educational, and interpretive value.

The establishment of baseline paleontological resource data is essential for the appropriate management of fossils found within National Park Service (NPS) areas. Although more than 190 NPS areas have been identified with paleontological resources, few parks have adequate baseline paleontological resource data.

In conjunction with the NPS Geologic Resources Division and the NPS Inventory and Monitoring (I&M) Program, paleontological resource inventories have been initiated in dozens of parks Servicewide and are further described in the Methodology and Inventory Strategies section of this report. This report presents paleontological resource inventory and monitoring data compiled for the parks of the Southeast Alaska I&M Network (SEAN).

The Southeast Alaska Network includes four National Park Service areas in the southeast portion of Alaska as shown in Figure 1. Glacier Bay National Park and Preserve (GLBA), Klondike Gold Rush National Historical Park (KLGO), and Sitka National Historical Park (SITK).

The parks that comprise the Southeast Alaska Network vary in size from 45.7 ha (113 acres; SITK) to nearly 1.12 million ha (2.77 million acres; GLBA). Together, the parks hosted nearly 1.8 million visitors in FY2007. Southeast Alaska consists of a narrow stretch of coastline and offshore islands between British Columbia and the Pacific Ocean. Thousands of islands south of Glacier Bay are known as the Alexander Archipelago. Most of Southeast Alaska consists of steep, rocky terrain, with a landscape dominated by glacial activity. The coastline and islands are dominated by fjords.

Southeast Alaska is part of the extensive cordillera along the west coast of North America. The northern portion of the cordillera consists of fault-bounded blocks of crust known as exotic terranes. Many of the terranes contain rocks which range from Precambrian to Ordovician in age, recording 500 million years (or more) of Earth history before accretion to the North American cratonic margin during the last 100-200 million years. The Fairweather Range and the contiguous St. Elias Mountains form the highest mountains along the north Pacific coast. Mt. St. Elias is 5,408 m (18,008 ft) and Mt. Fairweather is 4,600 m (15,300 ft) in height. Continued northward movement of the Pacific plate results in ongoing uplift.

The Coast Mountains are a north-south trending chain on the eastern boundary of Southeast Alaska consisting of metamorphic and plutonic rocks of the Coast Plutonic Complex. A sequence of less metamorphosed rocks occurs west of the Coast Mountains and is recognized as the Insular superterrane. Silurian fossils in the Alexander arc terrane show that this crustal fragment was located along the sub-equatorial Uralian Seaway (proto-Arctic Ocean) during the Silurian and Devonian. This superterrane is believed to have been transported from thousands of miles west and then south from earlier locations. The Alexander, Wrangellia, and Chugach terranes, along with the Gravina Belt are part of the Insular superterrane.

During the last seven million years thick ice sheets carved the high range of coastal mountains and mountainous islands along the coast. Glaciers continue to shape the rugged landscape of Southeast Alaska and glacier features dominate the landscape. Southeast Alaska is world-renowned for tidewater glaciers and the calving of glacial ice to form icebergs. The many fjords and channels are the result of glacial erosion.

The coastline along Southeast Alaska has been shaped by changes in global sea level since the last glacial maximum. The melting of the glaciers has led to regional isostatic rebound of areas formerly depressed under the weight of the glacial ice. The sea level changes and the isostatic rebound have influenced the modern coast through scouring of bedrock and the development of wave-cut sea stacks and sea caves. These areas are typically denuded of vegetation.

Ecologically Southeast Alaska is a temperate rain forest which is heavily forested with conifers at elevations below 500 m. Annual precipitation ranges from between averages of 254-762 cm (100-300 inches) of rain per year at Glacier Bay to only 71 cm (28 inches) per year at the Klondike Goldrush and Skagway area. The abundance of water supports lush vegetation controlled by drainage. In areas where water can escape, such as karst areas or steep slopes, trees can grow very large. In wetland areas with streams, lakes, ponds, and bogs (muskegs), trees are smaller (stunted) and sometimes absent. The forests form a tall canopy with dense ground cover of ferns and mosses. The most common tree species are western hemlock, Sitka spruce, and western red cedar.

Caves on Prince of Wales Island and one cave in Glacier Bay National Park (Ai Chi Pit) contain the remains of Pleistocene fauna. Although most of Southeast Alaska was probably covered by ice during the Pleistocene, the fossil remains from the caves suggest an ice-free area of land along the coast of Southeast Alaska during the Wisconsin glacial stage. The first vertebrate fossils were discovered from caves on Prince William Island in 1990. Since this discovery, intensive paleontological excavations and research has helped to construct a chronology of Late Pleistocene / Holocene terrestrial vertebrate refugia in the Southeast Alaska.

Collectively, the paleontological resources of the SEAN Network, in particular from GLBA, contribute to a greater understanding of the history of life on earth. Continued paleontological resource inventories will serve to expand this ever-widening base of paleontological knowledge represented throughout the National Park Service. Although more than 190 parks have already been identified as containing paleontological resources, much of what is to be known about the history of life on earth remains to be discovered.

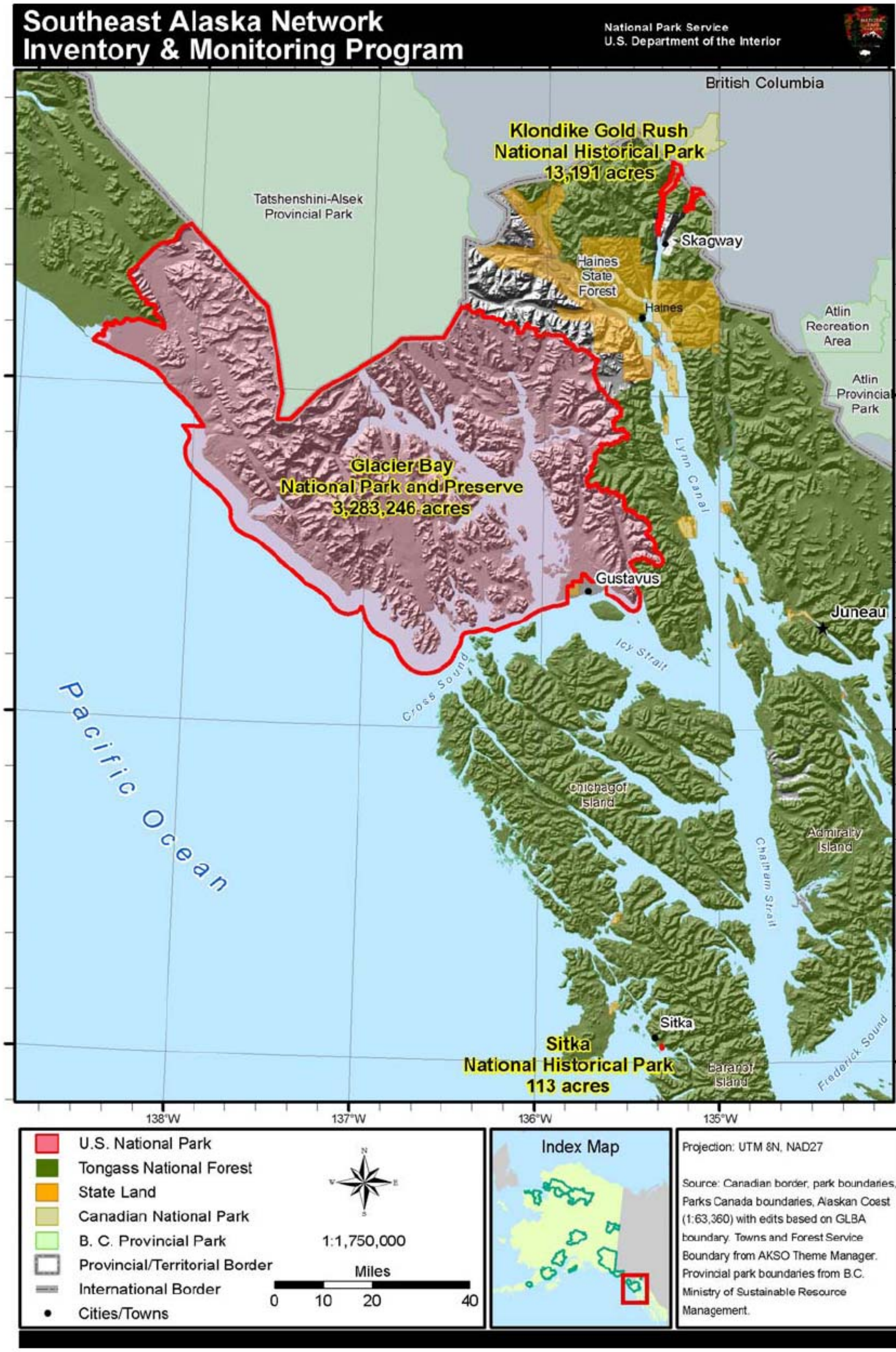

Figure 1. Map of SEAN network parks. Map courtesy SEAN staff.

Paleontological Resource Inventory Strategies and Methodology

To better document fossil occurrences and to provide baseline paleontological resource data in National Park Service areas, the NPS Geologic Resources Division (GRD) and the NPS Inventory and Monitoring Program (I&M) have established three paleontological resource inventory strategies, each with its own goals and objectives. These strategies include: comprehensive park-specific paleontological resource inventories, Servicewide thematic paleontological resource inventories, and Inventory & Monitoring Network-based baseline paleontological resource inventories. Santucci and Koch (2003) outline basic paleontological resource monitoring strategies and potential threats to fossil resources.

Comprehensive Park-Specific Paleontological Resource Inventories

Comprehensive park inventories are designed to identify all known paleontological resources within a single park unit. A team of specialists from within the NPS and from educational institutions and cooperators work with the targeted park to identify and address all aspects of its paleontological resources, including resource management, museum curation, law enforcement, and interpretation. Paleontology-specific training for park staff is an important component of many comprehensive paleontological inventories. Park-specific comprehensive paleontological resource inventories have been completed at Yellowstone NP (first park to have inventory completed), Amistad NRA (in review May 2008), Arches NP, Bighorn Canyon NRA, Death Valley NP, Grand Teton NP, Santa Monica NRA, Walnut Canyon NM, and Zion NP.

Servicewide Thematic Paleontological Resource Inventories

Servicewide thematic paleontological resource inventories compile data regarding specific types of paleontological resources that occur in parks throughout the NPS. The first thematic paleontological resource inventory identified 19 NPS units that preserve fossil vertebrate tracks (Santucci et al. 1998). Subsequent discoveries have increased the number of parks identified with fossil vertebrate tracks to 25 and warranted an updated publication (Santucci et al. 2006). Another thematic inventory identified paleontological resources associated with NPS caves in 35 parks (Santucci et al. 2001). Cave fossils occur in two contexts: First, fossils can be preserved in the marine limestones in which caves develop; second, the remains of Pleistocene/Holocene animals and plants that lived, died or were transported into caves after death are common types of cave fossils. Servicewide thematic inventories have also been initiated for fossil fish (Hunt et al. 2006) and fossils found in cultural resource contexts (Kenworthy and Santucci 2006).

Inventory and Monitoring Network Paleontological Resource Inventories

Network-based paleontological resource inventories compile baseline paleontological resource data for each of the parks within a particular network. As of May 2008, network-based inventories have been completed for 20 of the 32 I&M Networks including: the Appalachian Highlands, Chihuahuan Desert, Eastern Rivers and Mountains, Great Lakes (in review May 2008), Greater Yellowstone, Gulf Coast, Mediterranean Coast, Mid-Atlantic, Mojave Desert, National Capital Region, Northeast Coastal and Barrier, Northern Colorado Plateau, Pacific Island, Rocky Mountain, San Francisco Bay Area, Sierra Nevada, Southern Plains, Southeastern Alaska (this report), Southwestern Alaska, and Upper Columbia Basin networks. Research for summaries of the Arctic, Central Alaskan, Northern Great Plains, South Florida/Caribbean and Southeast Coast networks are currently underway. NPS I&M Program funding is targeted to complete paleontological resource summaries for the remaining networks by the end of FY2009. Citations for the completed reports are in the Additional References section.

I&M Network Paleontological Resource Inventory Methodology

Network-based paleontological inventories were funded directly by the individual networks from 2002-2006. In FY2006, the National I&M Program provided funds to complete reports for the remaining networks between FY2006-2009. These funds provide stipends or salary for contractors, interns, or paleontological technicians who perform data mining activities. A brief summary outlining the basic techniques used to assemble an I&M Network-based inventory follows below.

The most valuable component of any paleontological resource inventory is an intensive literature search. Various databases contain citations for geology or paleontology themed publications. The American Geological Institute's GeoRef is the primary database for geology references and contains millions of references from the middle 1700s through today. GeoRef, available in both online or CD-ROM versions, is accessible at many major university libraries. The NPS NatureBib (which supersedes PaleoBib) is an internet-based database for scientific citations presented as bibliographic references but does not yet contain a comprehensive paleontology bibliography. The USGS Library in Reston, Virginia is a premier repository for geologic publications, and houses most of the publications obtained for the network-based paleontological resource inventories. Additionally, museum libraries such as at the Smithsonian Institution's National Museum of Natural History, and university libraries provide access to a wide range of geological and paleontological publications. Individual state geological surveys are also excellent sources of information as are geologists familiar with local geology and paleontology.

The literature search also includes unpublished material (gray literature) from individual park files, museum archives, local newspapers, field notes, etc. These are often excellent sources of anecdotal information about park resources. In addition to literature searches, interviews with park staff, university faculty, geologists from the USGS and state surveys, and even local amateur geologists or paleontologists can yield information regarding park paleontological resources. These interviews frequently result in capturing data that might otherwise be undocumented and potentially lost or unrecognized. Bibliographic searches include a search for geologic maps associated with each park. The NPS Geologic Resources Division maintains a database of geological map coverage for many parks (current contact is Tim Connors). In addition, the USGS National Geologic Map Database (NGMDB; see citation below in Additional References section) lists maps for a given geographic area or place name and provides information on where to obtain maps. Geologic maps show the types of rocks and the associated geological formations within a park area. These maps, alone, will often indicate the potential for paleontological resources to occur within a park.

For the NPS areas in Alaska, the Alaska Paleontological Database is an extremely valuable source of information regarding paleontological localities. This paleontological database contains detailed information on fossils and fossil localities in Alaska. The database is supported through Congressional funding for the Minerals Data and Information Rescue in Alaska (MDIRA) project. The information utilized is derived from unpublished US Geological Survey fossil reports, published literature, as well as available industry data. Fossil locality searches are available by USGS quadrangles. The database has been created by Dr. Ning Zhang and Dr. Robert B. Blodgett (www.alaskafossil.org).

Fossils are most commonly found in sedimentary rocks such as sandstones, shales, and limestones. Fossils, with few exceptions, are not found within igneous rocks (volcanic or intrusive origin) or metamorphic rocks (altered by heat, pressure, and/or chemical change) due to the extreme heat and/or pressure associated with their origin and history. The nomenclature for geologic formations can be confusing, but the NGMDB includes a searchable lexicon of valid geologic formation names that can be very useful in clearing up nomenclatural confusion. This lexicon provides a basic summary for each formation, summarizes current and past usage of the various formation names found in the literature, and provides an annotated bibliography for each formation.

The information from these various sources for each park is then compiled and summarized in a written report and developed into individual datasets. The reports undergo peer review by professional geologists, paleontologists, and staff from each park for accuracy before being submitted to the network. These reports are designed to consolidate baseline paleontological resource data for each park to support management operations and decision-making. Therefore, the reports are written in NPS language and in addition to the scientific information, the reports address issues of resource management, protection, and interpretation.

The paleontological resource inventory reports synthesize information regarding the scope and significance of fossils documented from each park. Fossils are assessed and organized based upon taxonomy, stratigraphy, and paleoecology. Paleontological resources can be divided into six taxonomic groups: protists (unicellular plants and animals – typically plankton), microbes (fossil bacteria – typically found in stromatolites or as coatings on fossils), paleobotany (fossil plants), invertebrates (multicellular animals without backbones), vertebrates (animals with backbones), and trace fossils (evidence of biological activity such as tracks, traces, burrows, etc.). Fossils typically have a finite stratigraphic range and occurrence in geologic time (a geologic time scale is included in Figure 2). The period between the first and final occurrences of a fossil species is referred to as the stratigraphic range zone. Thus specific groups of fossils may be identified directly with a particular stratigraphic unit or stratigraphic range. Likewise, rock units often represent specific ancient sedimentary depositional environments. Paleoecologically, fossil groups may occur primarily, or in some instances only, in specific environmental conditions (temperature, aquatic, terrestrial, etc.). Thus many fossils may be useful as indicators of past environmental conditions. The reports are organized stratigraphically presenting the geologic and paleontologic information chronologically from oldest to youngest. Important fossils documented from localities outside a park are often reported in the park inventory, as these data may indicate the potential for fossils in similar stratigraphic units exposed within park boundaries.

Given the tremendous diversity of past life, the existence of life for over a billion years, and the range of environments to which life has adapted, there is a broad spectrum of research interests in paleontology. It is not surprising that most of what is to be learned about the history of life remains to be discovered. Through research, more than 190 NPS areas have been identified as containing paleontological resources. However, the paleontological research for a particular park may vary widely from an incidental fossil discovery to over a century of intensive paleontological investigations. The inventory reports include information on the history of paleontological research, descriptions of current cooperative projects, identification of any museums or universities serving as repositories for park fossils, and a comprehensive list of publications related to paleontological research associated with the park. The reports include all bibliographies that may be associated with a park's paleontological resources. However, bibliographic data are subdivided in the report into those cited in the narrative (References Cited) and other associated bibliographies (Additional References). The cooperative projects section highlights paleontological resources projects, if any, that the park has funded or supported. Formal datasets are established for known associated paleontological collections, research, or activities.

Paleontological Resource Management Legislation and Guidance

I&M Network reports such as this one are meant to provide network parks with sound baseline paleontological resource data that can stimulate future research, interpretation, education, or resource management projects. The proper management of resources identified through these inventories is mandated by many NPS policies. For example, the 2006 National Park Service Management Policies (§1.4.6) stipulates that paleontological resources are considered park resources and values that are subject to the "no impairment" standard set forth by the NPS Organic Act in 1916. Basic guidelines for management of paleontological resources are found in sections 4.8.2 and 4.8.2.1 of the 2006 NPS Management Policies. Another legislative protection for paleontological resources is found in the NPS Omnibus Management Act of 1998. Section 207, with the following statement, "Information concerning the nature and specific location of…paleontological objects within the units of the National Park System…may be withheld from the public source…," safeguards paleontological locality information from requests under the Freedom of Information Act.

Paleontological resource management issues were the subject of a Report of the Secretary of the Interior in May 2000, prepared in response to a Congressional request for an assessment of the need for a unified federal policy on the collection, storage and preservation of fossils and for standards that would maximize the availability of fossils for scientific study. That report, an "Assessment of Fossil Management on Federal & Indian Lands" summarized a number of principles relating to paleontological resources and their management. The Paleontological Resources Management section of Natural Resource Management Reference Manual 77 provides guidance and additional information regarding the implementation and continuation of paleontological resource management programs. Links to the above documents are listed in the Additional References section. The Geologic Resources Division is assembling a geologic resource monitoring manual that includes chapters on various geologic resources, including in situ paleontological resources, and a set of monitoring vital signs that may be applicable to a variety of parks. Monitoring represents the next phase in paleontological resource management, following the initial research inventory (represented by this report) of potential fossils and any subsequent field work to identify fossils within a park. Publication is expected by late 2008. Contact the Geologic Resources Division for more information or to obtain a copy of the report when it is available.

Our knowledge of the fossil record is only as good as our previous field season. The potential for new paleontological discoveries is proportionally related to our understanding as managers and stewards of this non-renewable evidence of life from the past. We believe that the baseline information provided in these reports and the resulting increased understanding of paleontological resources will inevitably result in paving the way for future fossil discoveries in NPS areas.

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General SEAN Information
SEAN I&M Network: http://www.nature.nps.gov/im/units/sean/index.cfm

Geological Survey Websites
Alaska Paleontological Database: http://alaskafossil.org
Alaska Division of Geological and Geophysical Surveys: http://www.dggs.dnr.state.ak.us/
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U.S. Geological Survey Library Catalog: http://igsrglib03.er.usgs.gov:8080/#focus
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Museums
Alaska Science Center, Anchorage: http://alaska.usgu.gov/index.php
University of Alaska Museum, Fairbanks – Museum of the North: http://www.uaf.edu/museum
Smithsonian National Museum of Natural History Dept. of Paleobiology: http://www.nmnh.si.edu/paleo/

Resource Management/Legislation Documents
NPS 2006 Management Policies (§1.4; Park Management): http://www.nps.gov/policy/mp/chapter1.htm
NPS 2006 Management Policies (§4.8.2.1; Paleontological Resources):
http://www.nps.gov/policy/mp/chapter4.htm
NPS 1998 Omnibus Management Act (paleontological resource summary):
http://www2.nature.nps.gov/geology/paleontology/paleo_5_1/index.htm
NPS Natural Resource Management Reference Manual #77 (paleontology section):
http://www.nature.nps.gov/rm77/paleo.cfm
Assessment of Fossil Management on Federal & Indian Lands: http://www.fs.fed.us/geology/fossil.pdf

National Park Service Paleontology Program sites
NPS Geologic Resources Division: http://www2.nature.nps.gov/geology/
NPS Paleontology Program: http://www2.nature.nps.gov/geology/paleontology/
NPS Park Paleontology Newsletter: http://www2.nature.nps.gov/geology/paleontology/newsletter.cfm
I&M Network paleontological resource summary project website and PDFs of all reports (InsideNPS):
http://inside.nps.gov/waso/custommenu.cfm?lv=4&prg=753&id=4518
NPS Technical Information Center (Denver, repository for TIC documents): http://etic.nps.gov/

Other geology/paleontology tools
Alaska Paleontology Database: http://alaskafossil.org
Bates, R. L. and J. A. Jackson (editors). American Geological Institute dictionary of geological terms (3rd Edition). Bantam Doubleday Dell Publishing Group, New York.
U.S. Geological Survey Geologic Glossary: http://wrgis.wr.usgs.gov/docs/parks/misc/glossarya.html
U.S. Geological Survey National Geologic Map Database (NGMDB): http://ngmdb.usgs.gov/
U.S. Geological Survey Geologic Names Lexicon (GEOLEX; geologic unit nomenclature and summary):
http://ngmdb.usgs.gov/Geolex/geolex_home.html
U.S. Geological Survey Geographic Names Information System (GNIS; search for place names and geographic features, and plot them on topographic maps or aerial photos): http://gnis.usgs.gov/
Paleobiology Database (search for fossil taxonomy, localities, or geologic formations):
http://paleodb.org/cgi-bin/bridge.pl
Paleontology Portal (general fossil info based on geographic location or geologic time):
http://www.paleoportal.org/
University of California-Berkeley Museum of Paleontology online paleontology exhibits:
http://www.ucmp.berkeley.edu/
U.S. Geological Survey, description of physiographic provinces: http://tapestry.usgs.gov/Default.html

Glacier Bay National Park and Preserve

Glacier Bay National Park and Preserve (GLBA) was originally proclaimed a national monument on February 25, 1925. The monument was created to preserve and protect the world-renowned tidewater glaciers, rich biodiversity of plants and animals, opportunities for scientific study of glaciers and related floral and faunal changes over time, and historic values associated with early explorers and scientists. The monument underwent a series of boundary expansions and on December 2, 1980 the site was established as a national park and preserve with over 1 million ha (2.5 million acres) of designated wilderness. Glacier Bay was also designated as a Biosphere Reserve in 1986 and a World Heritage Site in 1992.

Geologic Background

Glacier Bay National Park and Preserve is situated in the northwestern corner of Southeast Alaska. The park contains some of the largest and most active glaciers along the Pacific northwest coast. During the past 200 years the glaciers have retreated more than 96 km (60 miles). Lateral moraine deposits indicate that the glacial ice was once 900 m (3,000 ft) thick (Stowell 2006).

The GLBA landscape is dominated by several north to south trending mountain ranges. The Fairweather Range, which extends parallel to the coastline on the western portion of the park, is the highest of the mountain chains with numerous peaks over 3,048 m (10,000 ft) in elevation including Mount Fairweather at 4,663 m (15,300 ft) above sea level. The Takhinsha Mountains form the northeast boundary of GLBA and its eastern border occurs within the Chilkat Range and the Beartrack Mountains. The Saint Elias Mountains, Alsek Range, and the Brabazon Range comprise the northern and northwestern portions of GLBA.

A large portion of GLBA is covered by either water or ice. The entire western and southwestern portions of the park form a coastline with the Gulf of Alaska in the Pacific Ocean. Glacier Bay proper is a recently deglaciated system of fjords that run approximately 96 km (60 miles) from the mouth of the bay to up-bay tidewater glaciers. Along the southern boundary of the park, Icy Strait connects Glacier Bay and the Inside Passage of southeastern Alaska to the Pacific Ocean.

Buddington and Chapin (1929) published one of the earliest comprehensive works on the geology of Southeast Alaska. Miller (1951, 1961) produced geologic maps for the Yakataga District and Lituya District of Southeast Alaska. The most recent geologic mapping of Southeast Alaska was completed and published by Gehrels and Berg (1992). The park is represented by four 1:250,000 scale base maps including the Mount Fairweather, Juneau, Skagway, and Yakutat quadrangles.

The bedrock geology of GLBA is related to plate tectonic activity along the western edge of the North American plate. The subduction of the Pacific plate beneath the North American plate has resulted in the series of mountain ranges along the coastline in southeast Alaska. Blocks of oceanic crust called terranes, transported thousands of miles by plate movement over time, have collided with the North American plate in Alaska. Terranes are fault bounded geologic packages of regional extent characterized by a geologic history different from the surrounding terranes. These transported rocks represent three tectonic terranes: Alexander, Wrangellia, and Chugach (Brew et al. 1995) described below in chronological order.

Alexander Terrane (Ordovician-Permian)

The Alexander Terrane is composed of lower and upper Paleozoic oceanic sediments mixed with marine limestones, chert and volcanic rocks. Fossil invertebrates, graptolites, and conodonts preserved in the terrane limestones indicate carbonates formed during the Ordovician through Permian periods. These Paleozoic terrane rocks collided into the North American plate in southeast Alaska approximately 100 million years ago. Paleomagnetic data and similarities between the Silurian marine rocks and fossils in the Alexander Terrane and the Farewell Terrane (southwest Alaska), the Ural Mountains, and western

Siberia indicate the Alexander Terrane must have been located in the Uralian Seaway during the mid-Paleozoic (Bazard et al. 1995; Soja and Antoshkina 1997; Joyce 1999; Antoshkina and Soja 2006).

According to Constance Soja (Colgate University professor, pers. commun., 2008), the Silurian rocks in the Alexander terrane are preserved in the most continuous sequence of Silurian strata exposed in all of Alaska. Large areas within GLBA are composed of these Alexander Terrane rocks. The Marble Islands, Marble Mountains, Mount Wright, and Willoughby Island are composed of the Silurian limestones transported long distances by plate movement. Some of the Alexander Terrane rocks have undergone metamorphism from the original and subsequent tectonic events. The best examples are the metamorphosed limestones of the Marble Mountains which represent shallow marine carbonate deposition during the Silurian. However, in many areas the rocks are actually in good to nearly pristine condition. This is particularly true of the Willoughby Limestone on Drake Island where fossil preservation is equisite (C. Soja, pers. commun., 2008).

The following formations are associated with the Alexander terrane in GLBA: Willoughby Limestone, Heceta Formation, Tidal Formation, Rendu Formation, Pyramid Peak Formation, and Black Cap Limestone.

Wrangellia Terrane (Late Paleozoic-Triassic)
The Wrangellia Terrane is composed of late Paleozoic and Triassic carbonates, basalts, and phyllites. Wrangellia Terrane rocks originated near the equator and eventually joined with the Alexander Terrane by the middle Jurassic. During the early Cretaceous the Wrangellia Terrane collided with the North American plate resulting in deformation, metamorphism and large granitic intrusions. The rocks of the Wrangellia Terrane are compressed between the Alexander Terrane and Chugach Terrane in southeast Alaska, but have not been identified within GLBA.

Chugach Terrane (Mesozoic)
The Chugach Terrane is composed primarily of late Mesozoic turbidites including a mixture of greywacke, shale, and volcanic debris. These terrane rocks were scraped from the ocean floor and accreted onto the continent between the late Cretaceous and early to middle Tertiary. The Chugach Terrane exhibits deformation and the rocks are slightly metamorphosed. The Chugach Terrane is juxtaposed against much older rocks of the Alexander Terrane (Connor and O'Haire 1988).

Sources of Paleontological Resources

Early fossil collecting in the Glacier Bay area and other areas in the Gulf of Alaska was undertaken by U.S. Geological Survey field parties during the early 1900s. Fossil plants recovered during these early collections were first analyzed by paleobotanist F.H. Knowlton. Some fossil collections were made during mapping of the Gulf of Alaska by geologists such as D.J. Miller (1951; 1961) and George Plafker (1967). The most extensive collections were made of marine mollusks. Geologic investigations by the petroleum industry (British Petroleum Company and Shell Oil Company) resulted in collections of fossils from southeast Alaska.

Willoughby Limestone (Silurian)
The Willoughby Limestone is a Silurian marine platform carbonate unit and represents the oldest bedrock in GLBA (Soja 2008). The Willoughby Limestone is equivalent in part to the Heceta Formation exposed on Prince of Wales Island, with a well developed stromatolite reef complex associated with the Alexander Terrane. On Drake Island the Willoughby Limestone represents platform margin and outer lagoonal sediments capped by stromatolites and microbial cement (Soja et al. 2000). A shallow marine lagoonal facies include mollusk-rich jackstones deposited in low-energy subtidal conditions (Flynn et al. 1998)

In 1966 Ellis Yochelson (USGS) reported an extremely high-spired gastropod similar to *Coelocyclus* sp. from two localities on Drake Island. A decade later in 1976, Yochelson located another high-spired gastropod on the north end of Willoughby Island. Yochelson suggested this may be a new genus of high-spired gastropod with affinities to *Ptychocaulus*. The stromatoporoid *Amphipora* sp. and the rugose coral *Tryplasma?* sp. were collected from a clean limestone bed in the Willoughby Limestone on the north end of Willoughby Island.

In 2003, a new Silurian murchisoniid gastropod *Coelocaulus karlae* was discovered on and collected from a small island off the northeast end of Willoughby Island in GLBA (Rohr et al. 2003). A high-spired gastropod biorudite is documented from the Willoughby Limestone on Francis Island in GLBA.

Soja (2008) reports the presence of the megalobont bivalve *Pycinodesma*, aphrosalpinid sponges, and microbes *Hecetaphyton, Ludlovia*, and *Sphaerina* indicate a Late Silurian age. *Pycinodesma* megalodont bivalves and *Euomphalopterus* gastropods compose as much as 50% of rock volume.

The following fossil localities within the Willoughby Limestone of GLBA are referenced within the Alaska Paleontological Database:

Field Number 9-20-79B
Field Number 66-AOv-094
Field Number 66-AOv-213 (USGS Locality 7685-SD)
Field Number 66-AOv-222 (USGS Locality 7684-SD)
Field Number 75-CCO-098 (USGS Locality 9540-SD)
Field Number 75-CCO-099 (USGS Locality 9685-SD)
Field Number 993 of E. Kirk (1917)

Heceta Formation (Silurian)

The Heceta Formation is a Lower to Upper Silurian limestone unit which represents the first several episodes of reef development in the Alexander Terrane in southeastern Alaska. This unit crops out in the southern part of the Alexander Terrane, but is not identified within GLBA. This unit indicates the earliest evidence for the presence of a shallow marine platform in which the foundation reef formed.
Soja (1991) reports on massive stromatoporoids, corals, and red algae within fragmented rudstones which represent a fringing reef formed on the seaward edge of the marine shelf. Crinoids and the cyanobacteria *Girvanella* are accessory constituents of the reef. Small biostromes of ramose corals and stromatoporoids on oncolitic substrates developed in the backreef or lagoon (Soja 1991). Calcareous algae, cyanobacteria, amphiporids, brachiopods, and gastropods are also documented from the backreef deposits. The primary frame-builders of the barrier reefs were microbal taxa; aphrosalpingid sponges typically formed less than 25% reef volume and were the only common metazoans in the stromatolite reefs (Soja 1991; Soja and Riding 1993; Riding and Soja 1993; Soja 1994; Rigby et al. 1994; Soja et al. 2003). The similarity of these fossils to those in coeval deposits in Alaska's Farewell Terrane, the Ural Mountains, and western Siberia helps constrain the location of the Alexander arc terrane to the Uralian Seaway in the Silurian-early Devonian (Soja and Antoshkina 1997; Antoshkina and Soja 2006; Soja 2008).

Tidal Formation (Upper Silurian)

The Tidal Formation is a late Silurian-aged unit consisting of thin-bedded argillite, calcareous greywacke and limestone. This unit contains dipping sedimentary structures which indicate a turbidite-fan complex. The Tidal Formation is exposed in the Tidal Inlet region of the park (Rossman 1963). Tabulate corals are reported from one locality in GLBA including the genera *Favosites* sp. and *Striatopora?* sp.

The following fossil locality within the Tidal Formation of GLBA is referenced within the Alaska Paleontological Database:

Field Number 66-AOv-681 (USGS Locality 7686-SD)

Rendu Formation (Upper Silurian/Lower Devonian)

The Rendu Formation is a late Silurian or early Devonian-aged fine-grained carbonate unit. The unit contains some fossils including conodonts and rugose corals. Colonial rugose corals were documented at a locality in the Rendu / Queen Inlet area of GLBA.

The following fossil localities within the Rendu Formation of GLBA are referenced within the Alaska Paleontological Database:

Field Number 66-ABd-331A
Field Number 9-20-79A (USGS Locality 10144-SD)
Field Number 9-20-79C

Pyramid Peak Formation (Upper Silurian/Devonian)

The Pyramid Peak Formation is a late Silurian or Devonian limestone. The unit is recrystallized and has been suggested to be a distal tongue of the Willoughby Limestone. There is no references to fossils from the formation.

Black Cap Limestone (Devonian)

The Black Cap Limestone is a Devonian-aged, dark gray, fine-grained carbonate limestone. The faunal assemblage is interpreted as primarily Devonian with a few typical Late Silurian taxa. The presence of the brachiopod genus *Warrenella* strongly suggests a Devonian age for the assemblage.

In 1966, E.M. MacKevett Jr. made a collection of fossils from the Black Cap Limestone from a locality on the west side of Red Mountain, east of Muir Inlet. Stromatoporoids, tabulate corals and some undetermined rugose corals were obtained from the locality. The stromatoporoids were identified as *Amphipora* sp. and the tabulate corals include *Alveolites* sp., *Aulocystis* sp., *Favosites* sp., and *Thamnopora?* sp.

Between 1966 and 1972 several collections of fossils were made from USGS Locality 7701-SD which include tabulate corals, rugose corals, brachiopods, and ostracods. The tabulate corals include *Favosites* sp., *Oculipora?* sp., and *Thanopora* sp. The rugose coral was tentatively identified as *Pseudamplexus?* sp. The brachiopods belong to the genus *Atrypa*. The ostracod taxa include *Beyrichia, Hollinid, Clavofebellina?, Baschkirina, Praepilatina,* and *Aparchites.*

Several collections from USGS Locality 7702-SD include tabulate and rugose corals and two genera of brachiopods. The tabulate corals were identified as *Coenites* sp. and *Favosites* sp. The rugose coral was tentatively identified as the genus *Pseudamplexus?.* The brachiopod taxa included at least two species of *Atrypa* and the Devonian index fossil *Warrenella*.

Conodonts were collected from the Black Cap Limestone at Tidal Inlet south of Black Cap Mountain. The locality is described as a recrystallized algal-crinoid-gastropod bank with minor corals. The conodont collection included *Belodella resima, Panderodus* sp., paltodontiform elements, a neoprioniodiniform element, a plectospathodan element, and an ozarkodinan element.

The following fossil localities within the Black Cap Limestone in GLBA are referenced within the Alaska Paleontological Database:

Field Number 9-20-79E (USGS Locality 10145-SD)
Field Number 66-ABd-82B
Field Number 66-ABd-157B
Field Number 66-AFd-132a
Field Number 66-AMk-216 (USGS Locality 7683-SD)
Field Number 66-AWh-1 (USGS Locality 7701-SD)
Field Number 66-AWh-2 (USGS Locality 7704-SD)
Field Number 66-AWh-3 (USGS Locality 7702-SD)

Pybus Formation (Permian)
One GLBA fossil locality on the south side of the entrance to Adams Inlet is interpreted as Permian based upon the faunal content. The fossiliferous unit is situated at the base of a prominent and continuous limestone unit which is exposed about 4 km (2.5 miles) from the terminus of White Glacier. Although the geologic formation is uncertain, it is tentatively identified as the Pybus Formation.

The fossil material, including brachiopods, bryozoans and pelmatozoan debris, has been evaluated by J.T. Dutro who assigns the collection to Permian, most likely with a late Leonardian (Antinskian) age. The brachiopod taxa include *Septacamera stupenda, Spiriferella* sp., and *Stenoscisma?* sp. *Septacamera* is known from Permian rocks elsewhere in Alaska.

The Pybus Formation fossil locality is referenced within the Alaska Paleontological Database.

Field Number 66-AHx-115 (USGS Locality 25763-PC)

Coastal Igneous Rocks (Mesozoic)
Pre-Tertiary intrusive and extrusive igneous rocks occur along the coast and within the coastal mountains of GLBA (Pflaker 1961). The crystalline complex consists of granite, gneiss, schist and marble. The volcanic rocks are predominantly greenstone and volcanic greywacke, with minor argillite, chert, and limestone. Fossils do not occur in these igneous rocks.

Cenotaph Formation (Oligocene)
The Cenotaph Formation (or Cenotaph volcanics) is an early Oligocene-aged volcanic unit. The locality along the south shore of Cenotaph Island within GLBA is the designated type locality for the Cenotaph Formation. Pflaker (1961) includes the Cenotaph Volcanics within the Topsy Formation. Fossil plants are preserved in the Cenotaph Formation at GLBA and include *Lauraceae* sp., *Macclintockia pugetensis, Magnolia reticulate*, and *Pterocarya* sp.

The following fossil locality within the Cenotaph Volcanics of GLBA is referenced within the Alaska Paleontological Database:

Field Number 75-APr-37

Topsy Formation (Middle Oligocene-Miocene)
The Topsy Formation is a Middle Oligocene to Middle or Late Miocene-aged shallow marine deposit. This unit occurs in isolated outcrops extending north of Icy Point, along the Gulf of Alaska shoreline, along the distal edge of Finger Glacier, and in the Lituya Bay area of GLBA. This fossiliferous unit contains well preserved bivalves, gastropods and a fish vertebra (Marincovich 1980). The bivalve taxa include *Acila taliaferroi, Conchocele disjuncta, Lucinoma acutilineata, Macoma brota, M. incongrua, M. moesta, Nuculana* sp., *Periploma* sp. and *Spisula addicotti*. The gastropod taxa include *Beringius* cf. *crebricostatus*, *Calliostoma* sp., *Colus* sp., *Fusitriton oregonensis, Natica clausa, N. oregonensis*, *Neptunea plafkeri,* and *Turbinid* sp.

Wagner (1974) reports on the occurrence of sand dollar echinoids from the Topsy Formation in Lityua Bay, which represent the oldest known such fossils from Alaska.

The following fossil localities within the Topsy Formation of GLBA are referenced within the Alaska Paleontological Database:

Field Number 75-AM-65 (USGS Cenozoic Locality M6528)
Field Number 75-APr-40A (USGS Cenozoic Locality M6526)
Field Number 75-APr-43D (USGS Cenozoic Locality M6527)
Field Number 75-APr-45A (USGS Cenozoic Locality M6525)
Field Number 78-APr-54 (USGS Cenozoic Locality M7307)

Unidentified Unit (Upper Miocene)

Two upper (late) Miocene localities occur along the southern margin of Fairweather Glacier, 8 km (5 miles) due east of Cape Fairweather (Field Numbers 77-RMO-17C and 77-RMO-17F). The outcrops are composed of interlayered greywacke and siltstone beds. Within this undefined unit are vertical burrows, bivalves, and gastropods. The localities were extensively collected by George Plafker and Louie Marincovich in 1975. The mollusk species indicate a Late Miocene age for the unit and clearly suggest a cold water assemblage. The bivalve taxa include *Clinocardium* sp., *Lituyapecten* sp. and *Periploma besshoense*. The gastropod taxa include *Natica clausa* and *Turritella hamiltonensis*.

Unidentified Unit (Upper Miocene–Lower Pliocene)

Several fossil localities were identified in an unidentified mudstone unit near Cape Fairweather in GLBA (Field Number 60-AMr-114 and 60-AMr-223). The mudstone is believed to be either latest Miocene or early Pliocene in age based upon the fauna. Locality 60-AMr-114 represents an unusual assemblage of fauna not encountered in any other Alaskan collections. The bivalves include ?*Antiplanes* sp. (possibly a new genus), *Clinocardium comoxense, Macoma* cf. *brota, M.* cf. *calcarea, M.* cf. *incongrua, M.* cf. *nasuta, Megayoldia* cf. *thraciaformis*, and *Natica* cf. *clausa*.

The fauna from locality 60-AMr-223 is less diverse. The bivalves identified from this locality include: *Macoma* sp. and *Serripes hamiltonensis*. The gastropod taxa include *Buccinum* sp. and *Neptunea* sp.

Yakataga Formation (Middle Miocene-Pleistocene)

The Yakataga Formation is a middle Miocene to early Pleistocene-aged marine unit consisting of mudstone, siltstone, sandstone and minor conglomerate interbedded with tillite. This unit is characterized by unsorted, striated, and faceted clasts of diverse lithologies (Plafker 1967), recording episodic glacially-influenced marine sedimentation. The Yakataga Formation occurs within GLBA in outcrops along the coast between Lituya Bay and Icy Point, on an island in Lituya Bay, and north and south of Fairweather Glacier. This fossiliferous unit contains microfossils including forams and unidentified ostracods, as well as bivalves and snails (Kanno 1971). The age determination for the Yakataga Formation is based upon the marine mollusk assemblage (MacNeil et al. 1961). Analysis of forams from the Yakataga Formation provides the basis for interpretation of paleobathymetry and the depositional environments (Zellers 1990).

The foraminifera taxa of the Yakataga Formation include *Anomalina* sp., *Cassidulina californica, Cyclammina* sp., *Haplophragmoides* sp., *Lagena costata, Lenticulina sp*., and *Silicosigmoilina groenlandica*. The bivalve taxa include *Chlamys tugidakensis, Hiatella arctica, Macoma incongrua, Nuculana alferovi, Periploma* sp., and *Yoldia* sp. The gastropod taxa include *Colus* sp., *Natica clausa*, and *Neptunea lyrata*.

A second fossil locality in the Yakataga Formation is found along the edge of Fairweather Glacier in GLBA. The assemblage of bivalves and gastropods from this locality suggest a Middle to Late Miocene age for the outcrop. The bivalve taxa include *Cardium hamiltonensis, Clinocardium* cf. *yakatagensis, Cyclocardia* cf. *hamiltonensis, C. paucicostrata, Macoma brota, Mya* cf. *truncate, Patinopecten* sp., *Periploma cryphia, Portlandia* sp. *Siliqua* cf. *alta,* and *Spisula* sp. The gastropod taxa include *Buccinum* sp., *Neptunea lyrata,* and *Turritella* cf. *hamiltonensis.*

The following fossil localities within the Yakataga Formation of GLBA are referenced within the Alaska Paleontological Database:

Field Number 75-AM-21 (USGS Cenozoic Locality M6974)
Field Number Humble Oil Co. Cenozoic Locality FG-68-M1-M4 (USGS Cenozoic Locality M3977)

Thirty-eight species of Miocene-Pliocene age foraminifera were collected from a locality near La Perouse Glacier in GLBA. The data were reported in the Alaska Paleontology Database, but without information about the formation from which the microfossils were collected.

Forest Creek Formation (Upper Pleistocene)
The Forest Creek Formation is a shallow water, near-shore marine sedimentary unit. This unit contains an 11,000 year old volcanic ash bed in Granite Canyon in eastern GLBA. This is the only ash deposit known from this part of Alaska and is believed to be associated with Mt. Edgecumbe near Sitka (McKenzie 1970). Within the laminated ash are worm burrows (approximately 3 mm in diameter) which are infilled with a fine-grained green silt (McKenzie 1970).

Surficial Deposits (Pleistocene-Holocene)
Pleistocene and Holocene alluvium, colluvium, glacial till deposits, glacial erratics, and gravel cover large areas of GLBA. Glacial till within Tidal Inlet reaches thicknesses of up to 5 m (16.4 ft) on top of bedrock.

Holocene foraminifera and ostracods were collected from a pebbly marine clay east of Muir Inlet in the banks of Forest Creek. The foraminifera taxa include *Astrononion gallowayi, Bolivina pacifica, Buccella frigida, Cassidulina limbata, C. teretis, Cibicides lobatulus, Elphidium bartletti, E. clavatum, E. frigidium, Florilus labradoricus, Protelphidium orbiculare, Pseudononion auricula, Pyrgo lucernula, Quinqueloculina seminulum, Q. stalkeri,* and *Virgulina fusiformis.* The foram species suggest a nearshore or fjordland assemblage, rather than open ocean. The ostracods are typical cold water taxa and include *Cytheropteron* sp., *Loxoconcha* sp. and *Palmenella limicola.*

The following fossil localities within the Pleistocene/Holocene surficial deposits of GLBA are referenced within the Alaska Paleontological Database:

Field Number 66-AOv-1071A
Field Number 66-AOv-1071B

Caves were not known to occur in GLBA until recently. Extensive limestone deposits occur in some of the mountainous portions of the park. In 2001, a reconnaissance trip led to the discovery of twenty-one caves on Little Whitecap Mountain (W. Howell, GLBA Cultural Resources Manager, pers. commun., 2008). Most of the caves are vertical shafts, typically with water pouring through. A 70 m (230 ft) deep pit, informally named Ai Chi Pit, was discovered at an elevation of 700 m (2,297 ft) above sea level. Since the Wilderness Act does not permit the naming of features in wilderness areas, the cave pit is more commonly referred to as Cave 6. The mustelid skull was found at the base of the pit.

Heaton (2002a, 2002b, 2002c) has extensively studied Late Quaternary (Wisconsinan) fauna from cave deposits on Prince of Wales Island in southeast Alaska. A Late Wisconsin biochronology has been established for the ice age refugium of large mammals (Heaton and Grady 1997).

Fossil Forest – Muir Glacier
Naturalist John Muir was 41 years old when he first journeyed to GLBA in 1879. Muir discovered large quantities of wood and standing stumps that he referred to as fossil wood. In his famous book *Travels in Alaska* (1915), Muir frequently references his observations and encounters with fossil wood. The trees were buried by glacial outwash and provide data on glacial movement over time. Although the remains of these old trees are interstadial in age, they are actively collected and provide valuable data regarding the history of Holocene forest succession, paleoclimate and glacial activity (R. Yerxa, GLBA Writer-Editor and W. Howell, GLBA Cultural Resources Manager, pers. commun., 2008). The remains of Holocene willows and sedges are also preserved in some localities. Below are a series of passages referencing the fossil wood from Muir's *Travels in Alaska*:

June 23, 1890, *"…I pushed off alone into the silent icy prairie to the east, to Nunatak Island, about five hundred feet above the ice. I discovered a small lake on the larger of the two islands, and many battered and ground fragments of fossil wood, large and small. They seem to have come from trees that grew on the island perhaps centuries ago."*

June 25, 1890, *"In the old stratified moraine banks, trunks and branches of trees showing but little sign of decay occur at a height of about a hundred feet above tide-water. I have not yet compared the fossil* *wood with that of the opposite shore deposits. That the glacier was once withdrawn considerably back of its present limit seems plain. Immense torrents of water had filled in the inlet with stratified moraine material, and for centuries favorable climatic conditions allowed forests to grow upon it. At length the glacier advanced, probably three or four miles, uprooting and burying the trees which had grown undisturbed for centuries. Then came a great thaw, which produced the flood that deposited the uprooted trees. Also the trees which grew around the shores above reach of floods were shed off, perhaps by the thawing of the soil that was resting on the buried margin of the glacier, left on its retreat and protected by a covering of moraine-material from melting as fast as the exposed surface of the glacier. What appear to be remnants of the margin of the glacier when it stood at a much higher level still exist on the left side and probably all along its banks on both sides just below its present terminus."*

July 2, 1890, *"The stratified drift on the west side all the way from top to base contains fossil wood. On the east side, as far as I have seen it, the wood occurs only in one stratum at a height of about a hundred and twenty feet in sand and clay. Some in a bank of the west side are rooted in clay soil. I noticed a large grove of stumps in a washed out channel near the glacier-front but had no time to examine closely. Evidently a flood carrying great quantities of sand and gravel had overwhelmed and broke off these trees, leaving high stumps. The deposit, about a hundred feet or more above them, had been recently washed out by one of the draining streams of the glacier, exposing a part of the old forest floor certainly two or three centuries old."*

July 2, 1890, *"I descended a deep rock gully on the north side, the rawest, dirtiest, most dangerous I have seen hereabouts. There is also a large quantity of fossil wood scattered on this island, especially on the north side, that on the south side having been cleared off and carried away by the first tributary glacier, which being lower and melting earlier, has allowed the soil of the moraine material to fall, together with its forest, and be carried off. That on the north side is now being carried off or buried. The last of the main ice foundation is melting and the moraine material re-formed over and over again, and the fallen tree-trunks, decayed or half decayed or in a fair state of preservation, are also unburied and buried again or carried off to the terminal or lateral moraine."*

July 6, 1890, *"On my way back to camp I discovered a group of monumental stumps in a washed-out valley of the moraine and went ashore to observe them. They are in the dry course of a flood-channel about eighty feet above mean tide and four to five hundred yards back from the shore, where they have been pounded and battered by boulders rolling against them and over them, making them look like gigantic shaving brushes. The largest is about three feet in diameter and probably three hundred years old. I mean to return and examine them at leisure. A small stump, still firmly rooted, is standing astride of an old crumbling trunk, showing that at least two generations of trees flourished here undisturbed by the advance or retreat of the glacier or by its draining stream-floods. They are Sitka spruces and the wood is mostly in a good state of preservation. How these trees were broken off without being uprooted is dark to me at present. Perhaps most of their companions were up rooted and carried away."*

July 14, 1890, *"It is now half past ten o'clock and getting dusk as I sit by my little fossil wood fire writing these notes."*

July 15, 1890, *"I have been out on the glacier examining a moraine-like mass about a third of a mile from camp. It is perhaps a mile long, a hundred yards wide, and is thickly strewn with wood."*

July 17, 1890, *"I camped to-night on what I call Quarry Mountain from its raw, loose, plantless condition, seven or eight miles above the front of the glacier. I found enough fossil wood for tea."*

July 19, 1890, *"I went ashore to Granite Island and gleaned a little fossil wood with which I made tea on the ice."*

July 21, 1890, *"I had a fine telling day examining the ruins of the old forest of Sitka spruce that no great time ago grew in a shallow mud-filled basin near the southwest corner of the glacier. The trees were protected by a spur of the mountain that puts out here, and when the glacier advanced they were simply flooded with fine sand and overborne. Stumps by the hundred, three to fifteen feet high, rooted in a* *stream of fine blue mud on cobbles, still have their bark on. A stratum of decomposed bark, leave, cones, and old trunks is still in place. Some of the stumps are on rocky ridges of gravelly soil about one hundred and twenty-five feet above the sea. The valley has been washed out by the stream now occupying it, one of the glacier's draining streams a mile long or more and an eighth of a mile wide."*

Park Collections

In addition to the GLBA park collection, the largest collection of fossils from the park is maintained by Constance Soja at Colgate University. The Colgate collection consists of the Paleozoic fossils associated with the Alexander terrane. The assemblage of Silurian fossils probably represents the most important Silurian collection from any National Park Service area.

The GLBA park collections include the following paleontological resources (R. Yerxa, GLBA writer-editor, pers. commun., 2008):

- Three pieces of basal peat deposits were collected from a terrace above Echo Creek, north of Lituya Bay. This peat was dated to approximately 40,000 years before present (ybp) and represents the oldest such deposit known in the park. Collected in 1971 by J. Worley and Greg Streveler.
- Petrified wood (identified as conifer) was collected from the west side of Adams Valley by C.V Janda in 1970.
- Petrified wood (Anthophyta) was found on the beach at the old cannery site at Dundas Bay in 1964 by C.V. Janda.
- Fossilized cockles (Cordiidae(10,000 ybp) from Lituya Bay were collected in 1968.
- Fossil clams *Macoura* sp. (Tellinidae) were found in marine sediments (10,000 ybp) in Lituya Bay in 1968.
- Fossil moon snails (*Polinicea* sp.) were found in marine sediments (10,000 ybp) in Lituya Bay in 1968.
- A large primitive coral (Anthozoa), resembling Silurian coral *Zilophyllum*, was found south of Adams Inlet by C.V. Janda in 1966. Three mounted cross sections of the coral are cataloged in the collection.
- Fossil Lituya pectin, clams shells, moon snail and gastropods were found in marine sediments on Cenotaph Island, Lituya Bay in 1969.
- Fossil gastropods were collected from the Gloomy Knob locality (Willoughby) in 1969.

Paleontological Resources near Glacier Bay

Fossiliferous Devonian through Permian rocks occur outside GLBA on the Tongass National Forest near Prince of Wales Island. Devonian strata on Kasaan Island and nearby localities contribute to a greater understanding into the paleoecology, paleobiogeography, and evolutionary history of lineages that first colonized a series of offshore, oceanic islands (C. Soja, Colgate University professor, pers. commun., 2008). Typically oceanic islands are often destroyed via subduction during collision with the continental margins. The Alexander Terrane represents one of the best preserved Paleozoic island sequences in the world (C. Soja, pers. commun., 2008). Devonian rocks on Flame Island represent storm deposits (tempestites) that record mass spawning events in nautiloid cephalopods (Soja et al. 1996).

Paleontological Resource Management, Preliminary Recommendations

- At the time this report was completed the National Park Service Geologic Resources Division had not yet coordinated geologic scoping for GLBA.
- The park should consider future field inventories for paleontological resources to more fully document *in situ* occurrences of fossils. If any significant paleontological localities are discovered within GLBA, the park may consider a formal site documentation and condition assessment. Monitoring of significant sites should be undertaken at least once a year in the future.

- The standing trees in the Fossil Forest present an interesting taphonomic phenomenon worthy of future study. Research into the burial, deposition and preservation of the trees could be undertaken through a partnership with the U.S. Geological Survey or an academic institution.
- The park would benefit from the recruitment of a geologic intern through the National Park Service Geoscientist-In-the-Parks Program. The intern could help develop educational information regarding the geology and paleontology of GLBA.

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Klondike Gold Rush National Historical Park

Klondike Gold Rush National Historical Park (KLGO) was established on June 30, 1976. The park preserves and interprets the history and resources associated with the 1898 gold rush in Alaska. The park maintains over a dozen historic buildings in Skagway and includes portions of the Chilkoot and White Pass Trails.

KLGO consists of three separate units totaling 5,338 ha (13,191 acres) situated on the northern end of the Lynn Canal surrounded by steep, glaciated mountains. The park includes parts of both the Taiya and Skagway valleys which provide short pathways to glacier-free mountain passes connecting to the Canadian interior. The Taiya and Skagway rivers reach two of only three glacier-free passes through the Coast Ranges of Alaska. Therefore, KLGO is the area where the cold interior eco-region meets the Northwest Coast. The diversity of plant and animal species in Upper Lynn Canal represent the highest in Alaska.

Geologic Background

Klondike Gold Rush National Historical Park is located in Skagway on the northeastern corner of Southeast Alaska only a few miles from the Canadian border. The park lies on the west flank of the Coast Mountains (Coast Plutonic Complex) (Gehrels and Berg 1992). The Inside Passage extends to Skagway through the Lynn Canal, a long and straight fjord following the Chatham Strait fault. The Lynn Canal terminates in spectacular cliff exposures of Late Cretaceous to Paleocene tonalite and granodiorite near Skagway (Stowell 2006).

Potential Sources of Paleontological Resources

KLGO is surrounded by Cretaceous diorite and Cretaceous to early Tertiary granodiorite which has intruded into the older Mesozoic rocks. Although fossils are not known from the rocks within or around KLGO, a notable fossil locality occurs about 48 km (30 miles) southeast of Skagway. Near the south end of Taku Arm in Tagish Lake are relatively unmetamorphosed Triassic limestone beds which contain fossil ammonites as cited in the Alaska Paleontological Database.

Park Collections

The park curator at KLGO indicated that there were no fossils within the park collection (D. Sanders, KLGO Museum Curator, pers. commun., 2008).

Paleontological Resource Management, Preliminary Recommendations

- At the time this report was completed the National Park Service Geologic Resources Division had not yet coordinated geologic scoping for KLGO. Fossils are not known from the geologic units exposed within the park nor within park collections.
- Park staff should continue to be made aware of the potential for discovery of fossil material during other field work or construction activities, particularly along road cuts, stream banks, gullies, and other erosional features within the park.

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Sitka National Historical Park

Sitka National Historical Park (SITK) was originally proclaimed a national monument on March 23, 1910. The site was redesignated as a national historical park on October 18, 1972. The park preserves the site of the 1804 fort and last battle by the Tlingit who attempted to resist Russian colonization. The park maintains the Russian Bishop's House, built in 1842, which represents the oldest intact Russian-American architecture. Tlingit totem poles and crafts are exhibited at the park.

The Sitka area has a long history of mining with the first gold discoveries in 1871. Some of the richest gold deposits in Southeast Alaska occurred north of Sitka in the Chichagof district on the western portion of Chichgof Island (Stowell 2006). During World War II these gold deposits were mined.

The park preserves coastal lowland, riparian forest, the Indian River, intertidal marine coast, and estuarine areas of the Sitka Sound. The convergence of the Indian River, the coastal rainforest and the Pacific Ocean results in a biologically diverse flora and fauna at SITK.

Geologic Background

Sitka National Historical Park lies on the western coast of Baranof Island. Baranof Island is underlain by weakly metamorphosed, but strongly deformed rocks that were accreted to the older Wrangellia and Alexander terrane rocks (Stowell 2006). These include immature clastic sediments, volcanic rocks, and mafic igneous plutons of the Chugach terrane (Stowell 2006). During the Cretaceous (approximately 100 million years ago) rocks were scoured from the subducting oceanic plate (Pacific Plate) beneath the continental plate (North American Plate), forming an accretionary prism. As the accumulations of these rocks thickened, faulting and deformation produced a mélange referred to as the Kelp Bay Group and a sedimentary sequence known as the Sitka Greywacke (Gehrels and Berg 1992).

Potential Sources of Paleontological Resources

Kelp Bay Group (Cretaceous)
The Kelp Bay Group is a mixture of metamorphosed Cretaceous volcanic and sedimentary rocks that were tectonically mixed during subduction. These Chugach terrane rocks are largely a mélange (Stowell 2006). Mélange are rocks that are composed of unsorted rock fragments of varying sizes which lack stratification or continuous internal layers. Fossils are not known from this unit near SITK.

Sitka Greywacke (Cretaceous)
A greywacke is a poorly sorted, coarse grained, immature sandstone composed primarily of quartz, feldspar and rock fragments. Greywacke forms when dense sediment-laden bottom currents deposit in deep ocean troughs adjacent to continental margins (Stowell 2006). The Sitka Greywacke is exposed on the north and west end of the park (Berg 1963; Loney et al. 1975) and forms the rocky headlands along the beach south of SITK. This unit consists of thick sequences of sand and mud derived from volcaniclastic sediments shed into the Gulf of Alaska during the Cretaceous (G. Smith, personal communication, 2008). A greywacke is a poorly sorted, coarse grained, immature sandstone composed primarily from quartz, feldspar and rock fragments. Greywacke forms when dense sediment-laden bottom currents deposit in deep ocean troughs adjacent to continental margins (Stowell 2006). Fossils are not known from the Sitka Greywacke near SITK. However marine invertebrate fossils are reported from within the Sitka Greywache on Kruzof Island as cited in the Alaska Paleontological Database.

Volcanic Rocks and Modern Sediment (Cretaceous-Recent)
Locally Cretaceous and Tertiary plutons of tonalite and granodiorite intruded broad areas of Chugach terrane (Stowell 2006). To the west on Kruzof Island, Mt. Edgecumbe is a prominent 962 m (3,201 ft) tall composite volcano. Mt. Edgecumbe has been active for the past several million years and the most recent eruptions yielded ash deposits dating between 11,000 and 4,500 years before present (Beget and

Motyka 1998). A prominent 2.5-5 cm (1-2 in) band of 9,000 year old volcanic ash from Mt. Edgecumbe is preserved on the Sitka Greywacke in the town of Sitka.

Sedimentary rocks around Sitka represent some of the youngest sedimentary rocks in Southeast Alaska. Recent fluvial and beach sediments cover most of the park (G. Smith, SITK Biologist pers. commun., 2008).

Park Collections

The park curator at SITK indicated that there were no fossils in the park collection (S. Thorsen, SITK Museum Curator, pers. commun., 2008).

Paleontological Resource Management, Preliminary Recommendations

- At the time this report was completed the National Park Service Geologic Resources Division had not yet coordinated geologic scoping for SITK. Fossils have not yet been documented within the park, but do exist in similar formations outside of park boundaries.
- Park staff should continue to be made aware of the potential for discovery of fossil material during other field work, particularly along road cuts, streams, creeks, gullies, and erosional features of the park.

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Data Sets

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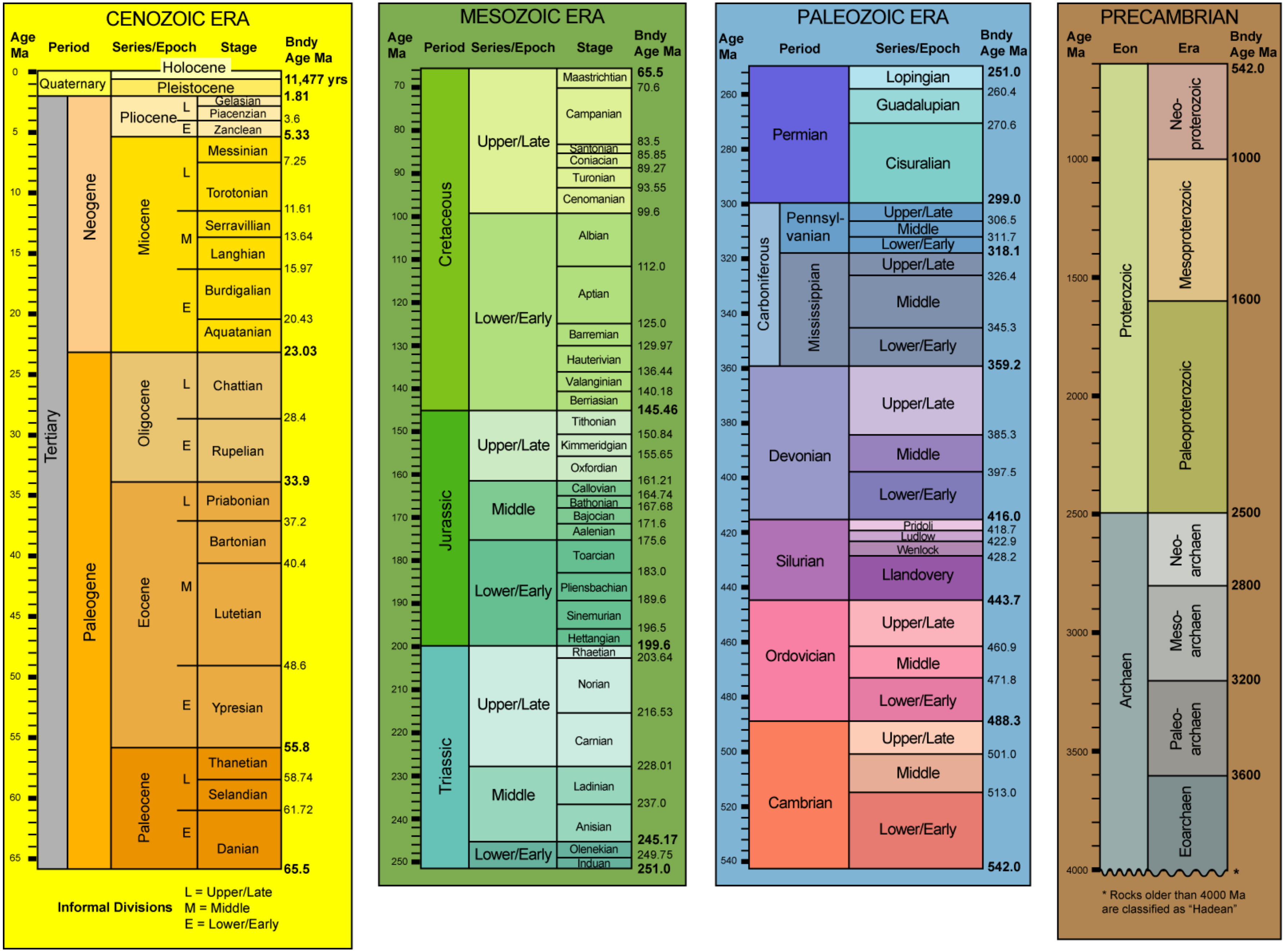

Figure 2. Geologic Time Scale. *Ma = Millions of year old. Bndy Age = Boundary Age*. Colors are USGS standard colors found on geologic maps. Modified from 1999 Geological Society of America Time scale (www.geosociety.org/science/timescale/timescl.pdf). Boundary dates and additional information from 2004 International Commission on Stratigraphy (www.stratigraphy.org/gssp.htm) and U.S. Geological Survey Fact Sheet 2007-3015 (http://pubs.usgs.gov/fs/2007/3015/).

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