Celebrate the National Park Service Centennial with 10 Fun Geology Facts

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On August 25, 1916, President Woodrow Wilson established the National Park Service (NPS) to oversee and manage our nation's national parks and monuments. Since 1916, the NPS mission has evolved to include the management and protection of over 400 park units that now also includes national historical and military parks, military cemeteries, national recreation areas, national scenic rivers, lakeshores, seashores, and trails.

This year marks the 100th year anniversary of the establishment of the National Park Service. To celebrate, the National Park Service has established several fun and exciting programs, including the "Find Your Park" campaign. Park-specific events will be occurring throughout the year. Information about centennial programs and events can be found at: https://www.nps.gov/subjects/centennial/index.htm

Geology and Our National Park Units

Geology is an important, if not the primary, reason why many parks are unique, inspiring, and beautiful, and thus deserving of national recognition and protection. Geology and geologic processes have sculpted and transformed the incredible and diverse landscapes entrusted to the NPS, ranging from the serene glacial-carved beauty of Yosemite Valley to the hydrothermal wonders of Yellowstone to the vast exposures of almost two billion years of geologic history in the rocks of the Grand Canyon.

To commemorate the 100th anniversary of the National Park Service, the Geologic Resources Inventory (GRI) Program Map Team has selected ten park units with significant and often spectacular geology. For each, we offer a brief history of the park, a snapshot of our digital geologic-GIS product for the park, and a "geology fact", complete with photographs and figures about each park's geology. Parks are presented in their establishment order, as indicated along the timeline at the base of the poster. Source maps and digital data used by the GRI for each digital geologic-GIS map are presented with that GRI map product.

Additional information about the NPS Geologic Resources Inventory (GRI) Program and our products, digital geologic-GIS map and geology reports, can be found in the lower right corner of this poster.

Hawai`i Volcanoes National Park, Hawaii

Hawai`i Volcanoes National Park is celebrating its Centennial along with the National Park Service in 2016.

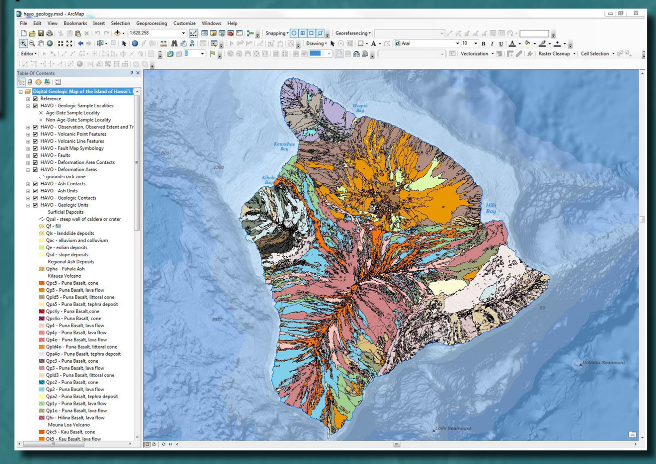
Hawai`i Volcanoes National Park contains the world's most massive mountain, Mauna Loa, at 13,677 feet above sea level. However, from its base on the sea floor, the volcano is more than 30,000 feet tall—1,000 feet higher than Mount Everest. The park also contains Kīlauea, the world's most active volcano.

Geology Fact #3

Kīlauea produces enough volcanic material every day to cover a football field to the height of the Washington Monument and has added more than 500 acres of new land since it's been erupting continuously since 1983.

Source: National Park Service

Kīlauea Caldera and Halema`uma`u Crater
View looking north-northwest across Kīlauea Caldera and Halema`uma`u Crater with Kulani Cone on the southeast slope of Mauna Loa in the distance. In the foreground is the lava flow of September 1982. The ledge nearly halfway up the wall of Halema`uma`u is the highest level of the 1967-68 lava lake. Light, slightly yellow patches indicate areas of chemical alteration near vents and fumaroles.
Source: http://hvo.wr.usgs.gov/kilauea/



Digital Geologic Map of the Island of Hawai`i, Hawaii
In contrast to explosive continental volcanoes, the more fluid and less gaseous eruptions of Kīlauea and Mauna Loa produce awe inspiring, fiery fountains, and rivers of molten lava that visitors can observe from a safe distance.

White Sands National Monument, New Mexico

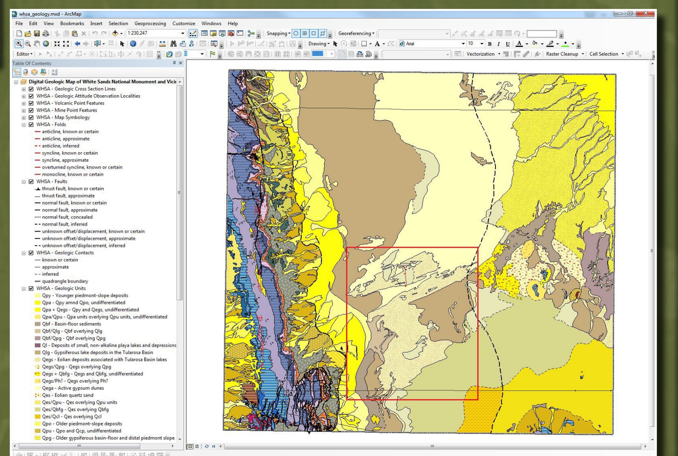
At White Sands National Monument rain and snow melt flow from the surrounding mountains into the closed Tularosa Basin. Water pools in various playas and evaporates slowly causing gypsum to be deposited in a crystalline form called selenite. The forces of nature break down the crystals into sand-size particles light enough to be moved by the wind and deposited in the White Sands dune field.

Geology Fact #6

Great wave-like gypsum sand dunes engulf over 275 square miles of desert and have created the world's largest gypsum dune field.

Source: National Park Service

Ripples in the sand
Evidence of sediment transport and wind direction indicated in ripples (foreground) and dunes (background).
Source: https://www.nps.gov/whsa/learn/photosmultimedia/Dune-Scenics.htm



Digital Geologic Map of White Sands National Monument
Mountains to the west in the darker colors and the Tularosa Basin and gypsiferous lake deposits and active dunes in the lighter colors to the right.

Wrangell–St. Elias National Park & Preserve, Alaska

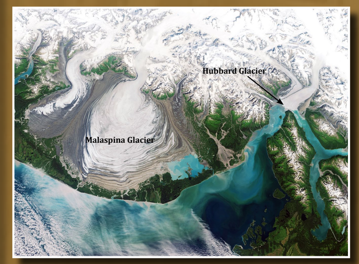
Hubbard Glacier
Tidewater terminus of the Hubbard Glacier in Russell Fjord with Gilbert Point visible on the left and the St. Elias Mountains in the background. October 30, 2013.
Source: NPS photo, (https://www.flickr.com/photos/wrst/10581435963/)

Wrangell–St. Elias National Park & Preserve (established as a National Monument in 1978 and Park & Preserve in 1980) is the largest area managed by the National Park Service with a total area of over 20,587 square miles, which is larger than the combined area of Massachusetts and Vermont. The park has been shaped by plate tectonics, volcanism, and glaciation. Glaciers cover approximately 25 percent of the park. The park also includes several volcanoes and a significant portion of the Saint Elias Mountains, which include peaks that rise dramatically as high as 18,008 feet (Mount St. Elias), yet are within 10 miles of the coast.

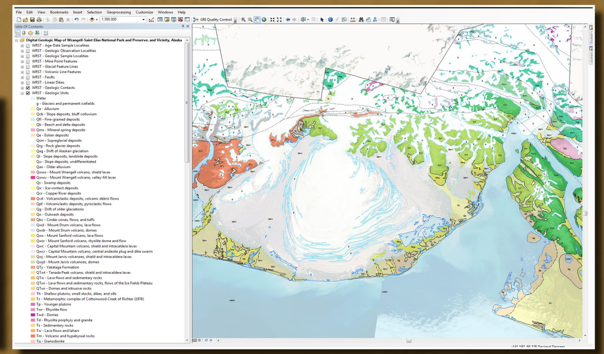
Geology Fact #9

The Malaspina Glacier is the largest piedmont glacier in the world; about the size of Rhode Island. The Hubbard Glacier is North America's largest tidewater glacier and is 76 miles long, 7 miles wide, and 600 feet tall at its terminal face, of which 250 feet is submerged.

Source: National Snow and Ice Data Center (https://nsidc.org/cryosphere/glaciers/gallery/piedmont.html), National Park Service (https://www.nps.gov/wrst/learn/nature/glaciers.htm)



Malaspina and Hubbard Glaciers
Malaspina Glacier (left) and Hubbard Glacier (upper right). July 22, 2014.
Source: NASA Earth Observatory, OLI Landsat 8



Digital Geologic Map of Malaspina and Hubbard Glacier area
The Malaspina Glacier forms where the Seward Glacier and Agassiz Glacier (along with a few smaller glaciers), spill out from the Saint Elias Mountains onto the coastal plain along the Gulf of Alaska between Icy Bay and Yakutat Bay. The Hubbard Glacier is 76 miles long and terminates in Russell Fjord and Disenchantment Bay.

Yellowstone National Park, Wyoming, Idaho, and Montana

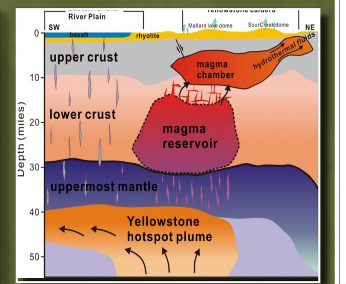
Grand Canyon of the Yellowstone by Thomas Moran (1872)
This painting, created after Moran's forty day expedition to the Yellowstone Region, helped illustrate the scale and beauty of Yellowstone, convincing President Grant and Congress that Yellowstone needed to be preserved. The U.S. government purchased the painting in 1872 for $10,000.
Source: Smithsonian American Art Museum, Gift of George D. Pratt, https://en.wikipedia.org/wiki/Thomas_Moran

On March 1, 1872, the Yellowstone National Park Protection Act was signed into law by President Ulysses S. Grant. The act states "the tract of land… lying near the headwaters of the Yellowstone River… is hereby reserved and withdrawn from settlement, occupancy, or sale under the laws of the United States, and dedicated and set apart as a public park or pleasuring-ground for the benefit and enjoyment of the people."

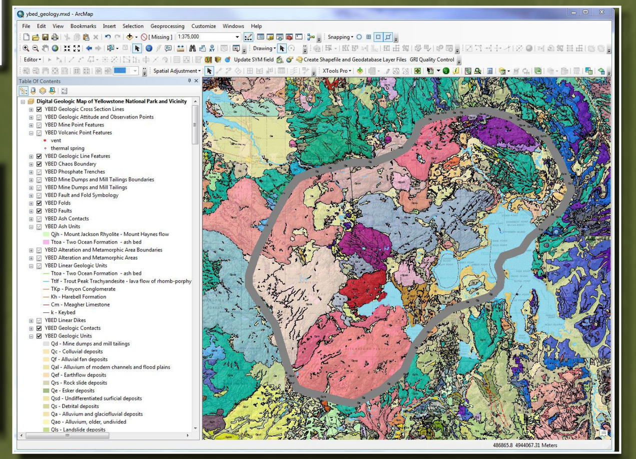
Geology Fact #1

New research suggests that a deeper and larger magma reservoir exists (see graphic to the right). This reservoir is over 4 times the size of the upper chamber and contains enough magma to fill the Grand Canyon (~1000 cubic miles in volume) 11.2 times.

Source: http://earthsky.org/earth/huge-magma-reservoir-discovered-under-yellowstone-supervolcano



Yellowstone Plumbing System
Cross-section under Yellowstone cutting southwest-northeast showing how molten rock is supplied from the Yellowstone hotspot to the Yellowstone supervolcano.
Source Hsin-Hua Huang, University of Utah

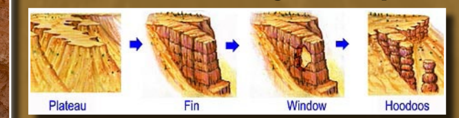


Digital Geologic Map showing the Yellowstone Caldera
The third Yellowstone caldera, shown in gray outline, was formed from the supervolcano's eruption 640,000 years ago. Rocks deposited from this eruption include the Plateau Rhyolite (unit symbols starting with "Qp" -- red, pink and gray polygons) and the Lava Creek Tuff (unit symbols starting with "Qy" -- green and blue-green polygons).

Bryce Canyon National Park, Utah

Hoodoos in Bryce Canyon National Park
The tall hoodoo in the forefront is known as Thor's Hammer
Source: Wikipedia (https://en.wikipedia.org/wiki/Hoodoo_(geology)). Photograph by Luca Galuzzi, 2007.

Bryce Canyon National Park (established as a National Monument in 1923 and a National Park in 1928), located in southwestern Utah, is known for its natural amphitheaters that contain numerous distinctive geologic features known as hoodoos. The hoodoos at Bryce Canyon are formed by weathering processes that erode the sedimentary rocks of the Eocene-age Claron Formation leaving tall thin spires of rock.



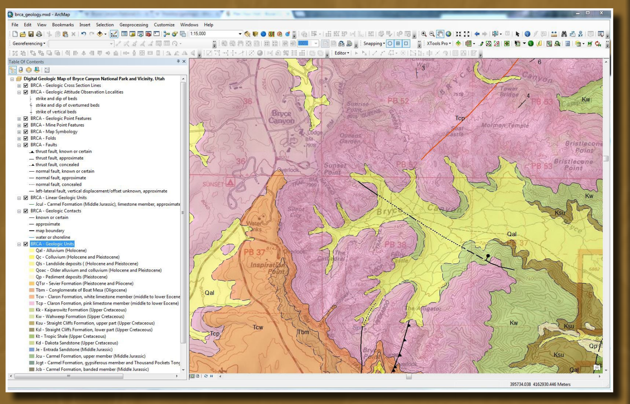
How do Hoodoos Form?
Drawings illustrating the general evolution of a hoodoo.
Source: National Park Service (https://www.nps.gov/brca/learn/nature/hoodoos.htm)

Geology Fact #4

At the top of a few hoodoos in Bryce Canyon the cap rock is an older Cretaceous-age rock (the Straight Cliffs Formation). This Cretaceous-age rock was thrust over younger Eocene-age rock (the Claron Formation). Geologists refer to a remnant of a thrust sheet as a "klippe". Could these cap rocks be the world's smallest klippen?

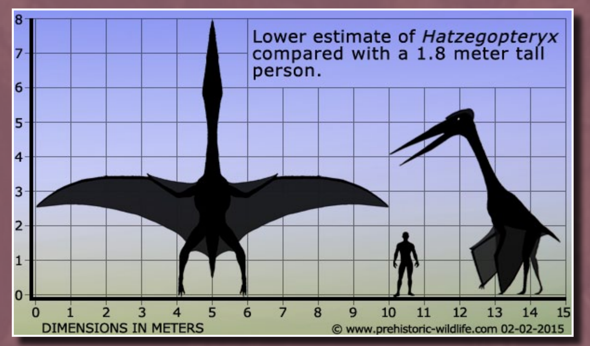
Source: Davis, George H, 1999, Structural Geology of the Colorado Plateau Region of Southern Utah: Geological Society of America, Special Paper 342, p 26-31, 157p.

Thor's Hammer in the fall
Source: National Park Service (https://www.nps.gov/brca/planyourvisit/index.htm). Photograph by Brian B. Roanhorse, 2014.



Digital Geologic Map of Bryce Canyon National Park and Vicinity, Utah
Geology in the Sunset Point area. Sunset Point is one of several visitor overlooks in Bryce Canyon that offer spectacular views of the park's many hoodoos and breath-taking geology. Hoodoos are predominantly found in the pink limestone member of the Claron Formation (unit Tcp).

Big Bend National Park, Texas



Quetzalcoatlus northropi
When it was fully grown, *Quetzalcoatlus northropi* had a wingspan as long as a school bus. Many scientists believe that it spent a significant portion of its time on the ground and it was thought to have a gait similar to that of a modern day vampire bat.
Source: http://www.prehistoric-wildlife.com/species/q/quetzalcoatlus.html

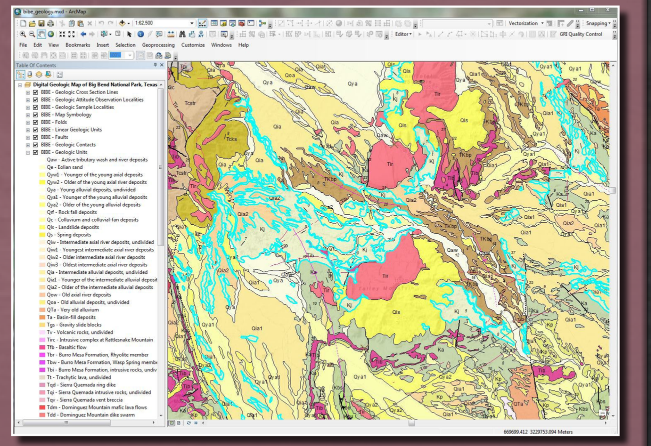
Big Bend National Park was established in 1944 to protect the largest tracts of Chihuahuan Desert topography and ecology in the United States. The park is famous for its natural resources, spectacular geology, and diversity of species. It has more types of bird, bats, and cacti than any other national park in the United States.

Geology Fact #7

The first fossils of *Quetzalcoatlus*, the largest known flying animal of all time with a wingspan of up to 12 meters, were found in 1971 in Big Bend National Park.

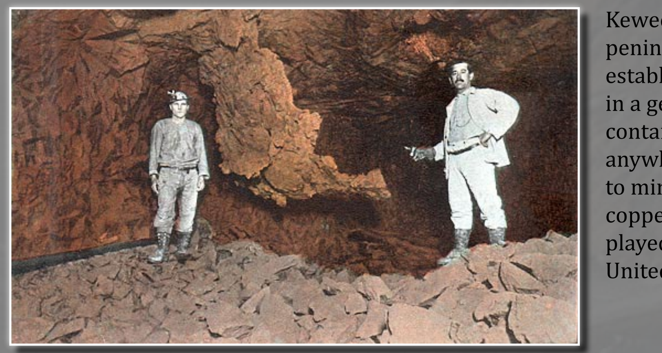
Source: Lehman, T.M., McDowell, F. and J. Connelly, J. (2006). "First isotopic (U-Pb) age for the Late Cretaceous Alamosaurus vertebrate fauna of West Texas, and its significance as a link between two faunal provinces." Journal of Vertebrate Paleontology, 26: 922–928.

Plaster Cast of a *Quetzalcoatlus northropi* Skeleton
Source: http://www.livescience.com images/i/000/014/454/i02/finished-Quetzal-110114-02.jpg



Digital Geologic Map of Big Bend National Park
Quetzalcoatlus lived approximately 68 million years ago. The first fossils were discovered in the Late Cretaceous Javelina Formation (unit symbol "Kj" -- tan polygons with light blue outlines).

Keweenaw National Historical Park, Michigan



Copper Mine
A mass of native copper hanging from the wall of a mine. This piece is approaching the largest size that could be handled without cutting up the copper in the mine.
Source: http://www.minsocam.org/MSA/collectors_corner/vft/mi3b.htm

Keweenaw National Historical Park is located on the upper peninsula of Michigan. The National Historical Park was established to preserve an extensive cultural history of mining in a geologically remarkable place. Lava flows in the area contain some of the largest volumes of copper found anywhere on earth. Over 7000 years ago native people began to mine Keweenaw copper to make tools and jewlery. These copper deposits were mined for coins and copper wire which played a pivotal role in the proliferation of electricity across the United States.

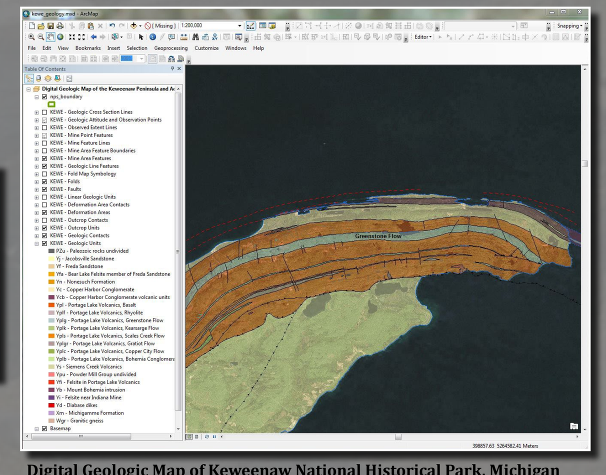
Geology Fact #10

1) Keweenaw National Historical Park is the only place on earth where large scale, economically recoverable, 97% pure, native copper is found.

2) Copper artifacts made by ancient Indians were traded as far south as present day Alabama.

Source: Source: Public Law 102-543 (Oct. 27, 1992); 106 STAT. 3569

Halfbreed Specimen from the Keweenaw Peninsula
Halfbreed is the term used for an ore sample that contains pure copper and pure silver in the same piece of rock. This particular specimen was most likely recovered from a mill becuase it is partially rounded. Halfbreed is only found in the native copper deposits of the upper peninsula of Michigan.
Source: http://www.mindat.org/min-11390.htm



Digital Geologic Map of Keweenaw National Historical Park, Michigan showing the Greenstone Flow and Surrounding Area
The lava flows are voluminous but did not travel far from their source. The Greenstone Flow accumulated within the rift zone to as much as 1500 feet.

Gettysburg National Military Park, Pennsylvania

Battle of Gettysburg: July 2, 1863
Overview map showing Union (blue) and Confederate (red) troop positions and movements on the second day of the battle.
Map by Hal Jespersen, www.cwmaps.com.

Gettysburg National Military Park was established in 1895 (transferred to the National Park Service in 1933) to protect the landscape of the Battle of Gettysburg, fought during the American Civil War.

Battle of Gettysburg (July 1 – 3, 1863)
The 3-day battle between the Confederate and Union armies would conclude the "high-water mark of the confederacy", and resulted in the largest number of casualties of any battle of the American Civil War.

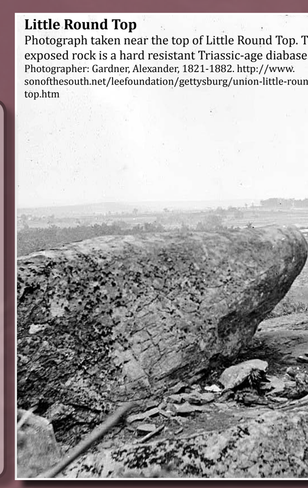
Colonel Joshua Chamberlain and the 20th Maine Rush to Little Round Top. Civil War print by Mort Kunstler.

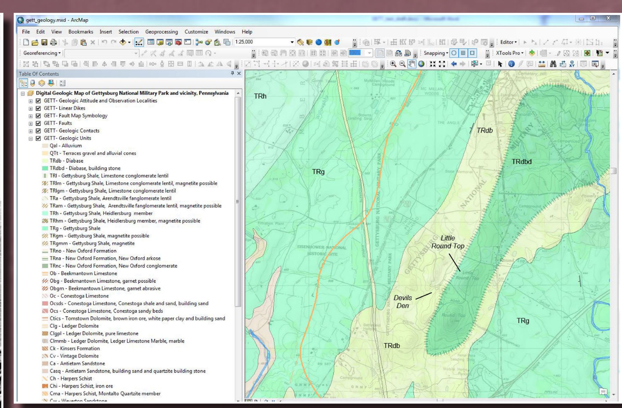
Geology Fact #2

At Little Round Top soldiers defending the southern end of the union line couldn't solidly "dig in" or entrench as the rock that forms the prominent hilltop is of a hard resistant Triassic-age diabase. As a result the defending union soldiers suffered higher than expected causalities compared to the attacking confederates.

Source: Brown, Andrew, 1962, Geology and the Gettysburg Campaign: Pennsylvania Department of Conservation and Natural Resources, Education Series 5, 16p. (http://www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr_014596.pdf)

Little Round Top
Photograph taken near the top of Little Round Top. The exposed rock is a hard resistant Triassic-age diabase.
Photographer: Gardner, Alexander, 1821-1882. http://www.sonofthesouth.net/leefoundation/gettysburg/union-little-round-top.htm





Digital Geologic Map of Little Round Top, Round Top and surrounding area
Little Round Top, elevation 63 ft is along Cemetery Ridge, a prominent north-south trending ridge line comprised of Triassic-age resistant diabase rock. The diabase, units TRdb and TRdbd, intruded into older sandstones and siltstone of the Gettysburg Formation (unit TRg) during the Triassic. The diabase is now recognized to be the Gettysburg Sill of the York Haven Diabase.

Grand Teton National Park, Wyoming

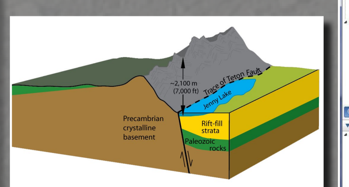
Snake River, Teton Range from Schwabachers Landing
Majestic peaks of the Teton Range rise sharply from Jackson Hole Valley. Peaks from left: Middle Teton, Grand Teton, Mount Owen and Teewinot Mountain. **Source:** National Park Service (www.nps.gov/grte/learn/photosmultimedia/photogallery.htm)

Grand Teton National Park was established in 1929 as a 96,000 acre park that included the central Teton Range and moraine lakes. In 1943, John D. Rockefeller, Jr. donated over 200,000 acres of Jackson Hole land to the federal government with the agreement that the land would be protected. President Franklin D. Roosevelt used the Antiquities Act to designate the donated land as Jackson Hole National Monument. In 1950, Grand Teton National Park and Jackson Hole National Monument were combined to form the present day Grand Teton National Park.

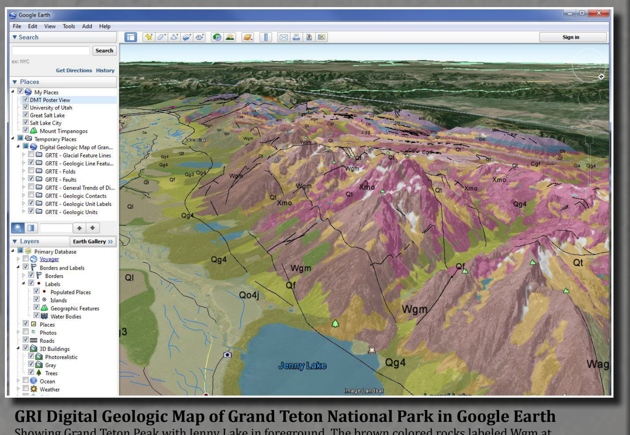
Geology Fact #5

The Teton Range is one of the youngest mountain ranges in the Rocky Mountains. Most of the Rocky Mountains were formed during the Laramide Orogeny (80 to 55 million years ago). Around 5 to 6 million years ago, movement along the Teton fault uplifted the Teton Range and formed Jackson Hole Valley.

Source: www.enjoyyourparks.com/GrandTetonParkFacts.html

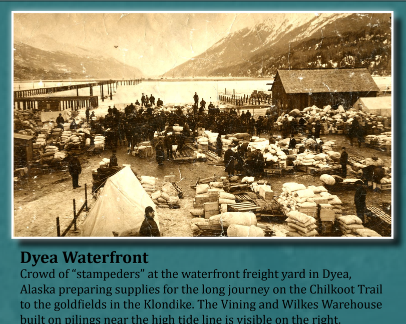


Teton Fault
The Teton Range rises more than 7,000 ft above the floor of Jackson Hole Valley. The Teton Range is part of the upthrown footwall block of the Teton fault, while Jackson Hole Valley is situated on the down-dropped hanging wall block.
Source: In the NPS GRI report for Grand Teton National Park -- modified from Lillie, R. J. 2005. Parks and plates: The geology of our national parks, monuments, and seashores. W. W. Norton and Company, New York, New York, USA by Trista Thornberry-Ehrlich (Colorado State University).

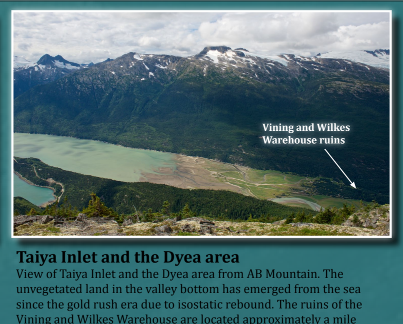


GRI Digital Geologic Map of Grand Teton National Park in Google Earth
Showing Grand Teton Peak with Jenny Lake in foreground. The brown colored rocks labeled Wgm at the base of the range are Late Archean (~2.5 billion years old) metamorphic rocks that are some of the oldest rocks in the United States.

Klondike Gold Rush National Historical Park, Alaska



Dyea Waterfront
Crowd of "stampeders" at the waterfront freight yard in Dyea, Alaska preparing supplies for the long journey on the Chilkoot Trail to the goldfields in the Klondike. The Vining and Wilkes Warehouse built on pilings near the high tide line is visible on the right.
Source: KLGO Historic Photo Collection, Michael Maslan Collection KLGO-475, KLGO Accession #10053. Photographer: E.A. Hegg



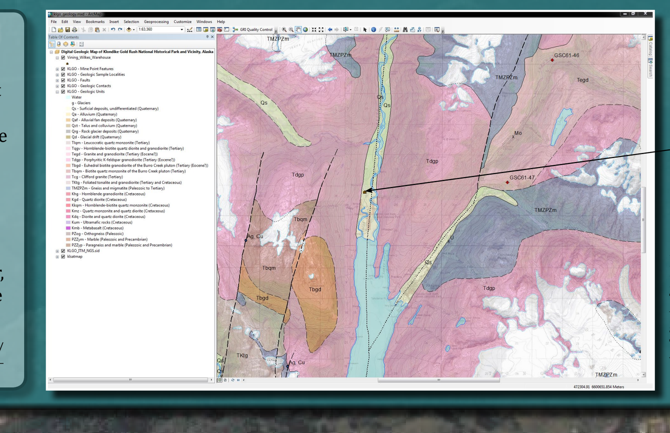
Taiya Inlet and the Dyea area
View of Taiya Inlet and the Dyea area from AB Mountain. The unvegetated land in the valley bottom has emerged from the sea since the gold rush era due to isostatic rebound. The ruins of the Vining and Wilkes Warehouse are located approximately a mile from the water in the forested area of the valley on the right side of the photo. August 2013. **Source:** Ron Karpilo

Klondike Gold Rush National Historical Park (established 1976) commemorates the 1890s gold rush in Canada's Yukon Territory. The park protects and interprets the historic boomtowns, buildings, and trails that served as staging areas and routes of travel during the Klondike Gold Rush. The park protects a significant portion of downtown Skagway, the historic town site of Dyea, and the Chilkoot and White Pass Trails.

Geology Fact #8

The Vining and Wilkes Warehouse at Dyea was built in 1898 on pilings near the high-tide mark. Now it is more than one mile away from the water due to approximately 5.4 to 7.5 feet of isostatic rebound. Rate of rebound in Southeast Alaska is between 0.55 and 0.76 inches per year, the highest known rate in the world.

National Park Service: (http://www.nature.nps.gov/geology/inventory/publications/s_summaries/KLGO_GRI_scoping_summary_2009-0930.pdf)



Digital Geologic Map showing Skagway, Dyea and surrounding area
The area of land (mapped as Qs) between the former town of Dyea and Tayia Inlet has emerged from the water as a result of isostatic rebound during the past century. The brown house icon on the map shows the former waterfront location of the Vining and Wilkes Warehouse.

The Geologic Resources Inventory

The Geologic Resources Inventory (GRI) is one of twelve inventories funded by the National Park Service after the Natural Resource Challenge in the 1990s. The goal of the GRI is to increase understanding of the geologic processes in parks and provide accurate geologic information for use in park decision-making. Sound park stewardship relies on understanding natural resources and their role in the ecosystem, of which geology is the foundation. The GRI program is a partnership between the NPS and Colorado State University (CSU), and relies heavily upon source maps and local expertise from the U.S. Geological Survey, state geological surveys, and other organizations to develop its products. CSU research associates work together with NPS staff to facilitate scoping meetings and produce GRI products.

Overview of GRI Products

The GRI produces 3 products to assist park management and staff in the management and protection of their park. The first product is a digital geologic-GIS map product that is available in three data formats: 1) an ESRI 10.X file geodatabase and accompanying 10.0 ArcMap document for use with ESRI ArcGIS software, 2) KML/KMZ file for use with Google Earth, and 3) an ESRI 10.2 map service for use with ESRI online web map applications such as ArcGIS Online, or other portal/viewer applications. In addition to the spatial data, each digital geologic-GIS product also contains an introductory readme file, FGDC-compliant metadata, and an ancillary map information document which contains unit descriptions and other ancillary source map graphics and information.

In addition to the geologic-GIS data the GRI produces a basic cartographic layout and a geologic report. The layout displays a park's geologic data over shaded relief of the area along with complete with prominent geologic and geographic features and localities. The report is a comprehensive document that presents a park's: 1) geologic significance, 2) geologic history, and 3) prominent geologic features, processes and issues.

All GRI products are available at http://go.nps.gov/gripubs

Software
ArcGIS 10.X, Environmental Systems Research Institute (ESRI) Inc., 380, New York St., Redlands, CA 92373, http://www.esri.com
Google Earth, Google Inc., http://www.google.com/earth/index.html
ESRI USA Topo, Imagery and World Shaded Relief Web Map Services, 2015 (topographic base map of USGS scanned topographic maps using National Geographic Society, i-cubed)

Timeline showing the establishment dates of the National Park Service Units presented in this poster.