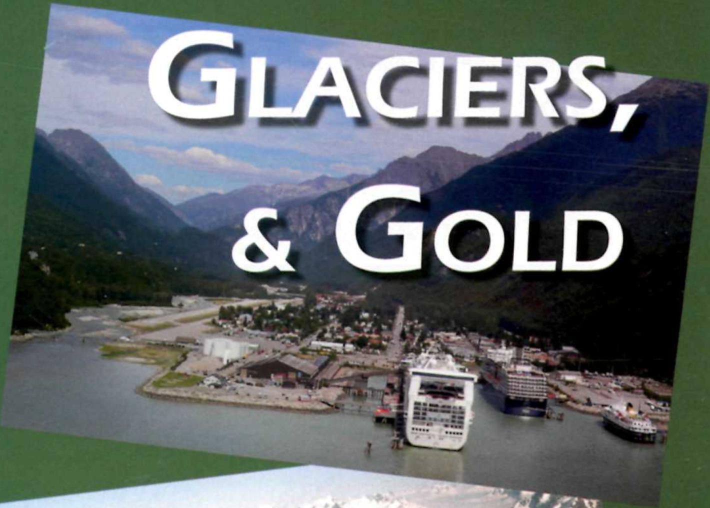
Klondike Gold Rush
National Historical Park
Skagway, Alaska

GEOLOGY, GLACIERS, & GOLD



WELCOME TO SKAGWAY!

Skagway is known for its gold rush history, but its natural history tells a fascinating story of its own. Understanding the forces that shaped the land here brings the breathtaking scenery alive.

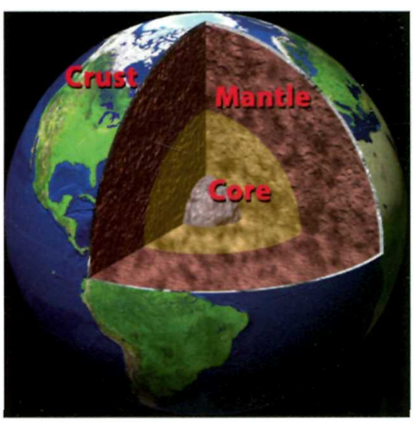
The following pages guide you through the local topography. They provide background information on the geologic forces which created the land, the glaciers that shaped it, and the gold that made it famous. The final section is a road log - use it while driving up the first 18 miles of the Klondike Highway to see examples of the features described in this brochure.

As you travel throughout Southeast Alaska, keep an eye out for features similar to those described here. Enjoy your visit to Skagway!

CREATION OF THE LAND

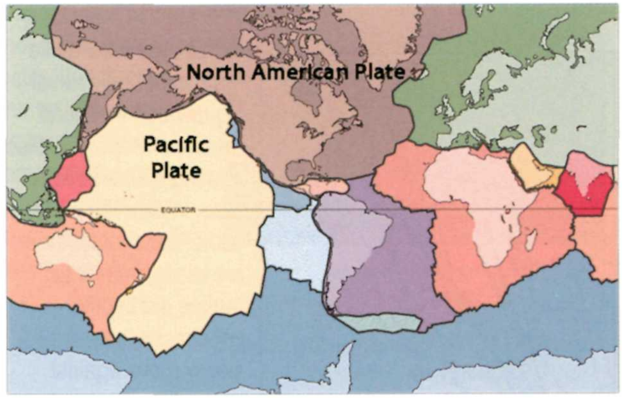
Many forces, acting on the land around Skagway over millions of years, determined the modern appearance of the Skagway River Valley. But the origin of the local landforms began deep within the earth.

A number of layers make up the interior of the earth. At its center is the **core**, which has a solid inside and a liquid outside. Surrounding the core is a thick, semi-solid layer of magma called the **mantle**. On top of the mantle lies the **crust**, our solid land and ocean floors, relatively thin in comparison to the entire planet.



Profile of the Earth's interior

The semi-solid mantle has currents, and flows very slowly. The crust floats on top and moves along with the currents. However, because it is a solid it cannot flow. It breaks into large chunks called **tectonic plates**.

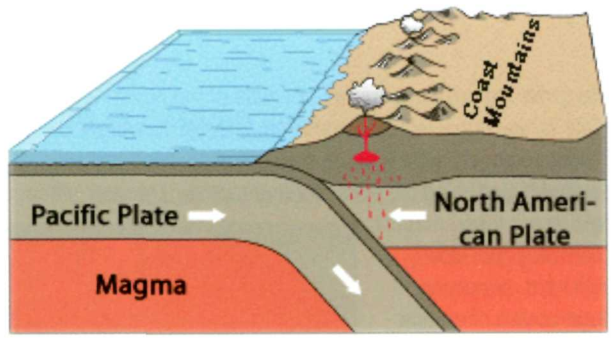


Global map of tectonic plates

There are 15 major tectonic plates worldwide. Southeast Alaska sits at the juncture of the Pacific Plate to the west and the North American Plate to the east. The flow of magma below forces these two plates together in a process called oceanic-continental convergence. The thinner Pacific Plate is being driven beneath, while the thicker North American Plate is overriding and crumpling up in the zone of contact.

FORMATION OF THE COAST MOUNTAINS

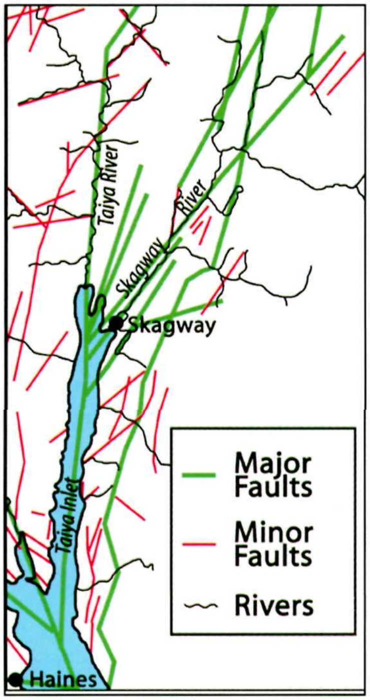
The collision of these two plates has resulted in three major types of geologic events: uplift, faulting, and magma injections.



Local tectonic motion

Uplift. The crumpling of the North American Plate where it strikes the Pacific Plate is causing the relatively smooth surface of the crust to buckle and rise, similar to the hood of a car involved in a front-end impact. The land is lifting up to form mountains. The Coast Mountains surrounding the Inside Passage and Skagway are the result of this process of uplift.

Faulting. Just as the hood of a car forms dents and cracks under impact, the solid crust fractures under the pressure of oceanic-continental convergence. Fractures along which movement or slippage takes place are called faults, great cracks and lines of weakness in otherwise solid bedrock.



Local faults

In this area the Pacific Plate is not only traveling towards the North American Plate, it is also rotating counterclockwise. Where the plates come into contact there are many faults that radiate out in different directions as they slowly move against each other. Energy from the plates' movement spreads out among all the fault lines instead of concentrating in one. As a result, Skagway frequently experiences earthquakes that are too small to feel.

It's common for rivers to find these lines of weakness to be the paths of least resistance. Some of the region's many faults lie below the Skagway and Taiya River Valleys.

Magma Injections. The underside of the North American Plate is also impacted by oceanic-continental convergence. Fractures beneath the surface are commonly filled and expanded by intruding lava-like molten magma. Trapped within solid crust, these magma chambers cool slowly until hard, becoming huge bodies of granite called plutons. Uplift raises these plutons. Millions of years of weathering and erosion eat away at the miles of material on top of the plutons, eventually exposing them as the massive granite mountains north of Skagway.

Exposed pluton

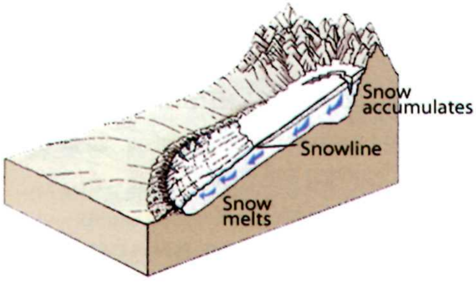
GLACIERS REFORM THE LAND

GLACIERS ARE RIVERS OF ICE

Glaciers form at high, cold altitudes where snowfall accumulates faster than it melts. The weight of increasing layers of snow compacts the older layers into ice. The mass begins to slide downhill, a slowly flowing river of ice.

Meade Glacier

A glacier consists of two parts: first, an area of gain (accumulation) where new snow is added to the glacier each year; second, an area of loss (ablation) where mass is lost each year to melting and calving. These two areas are divided by a **snowline**. As the glacier flows downhill it grows thinner and narrower.

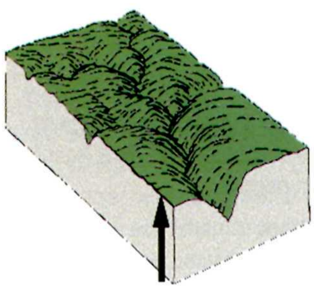


Snow becomes a river of ice

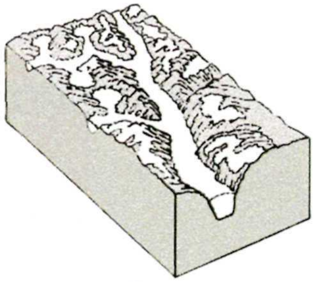
Ultimately it reaches a point where the ice front advances no further, because the ice there melts as rapidly as ice flows down from above.

GLACIALLY CARVED VALLEYS

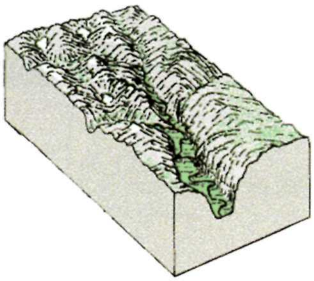
Like water, glaciers follow the path of least resistance and reshape the land as they flow through. The process of glaciation follows these three general steps:



1) Uplift causes running water to cut a **V-shaped** valley.



2) Glaciers fill the river valley, widening and straightening the channel, into a U-shaped valley.

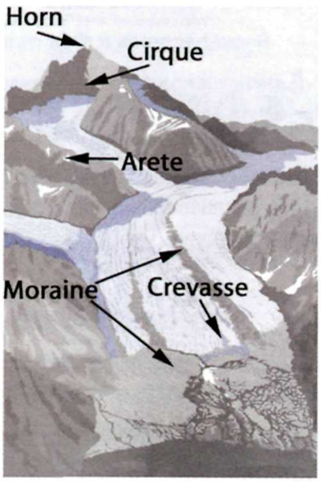


3) Glaciers melt, revealing the **U-shaped** valley. If the sea later fills in the valley, it is called a **fjord**.

FEATURES OF A GLACIAL LANDSCAPE

Cirque - A bowl-shaped basin at the head of a glaciated valley produced by glacial scouring and erosion.

Crevasse - Open fractures or breaks in glacial ice. As ice flows, the base of a glacier moves more slowly than the surface, producing deep cracks and crevices in the surface of a glacier.



Arete - A narrow ridge separating two glaciated valleys.

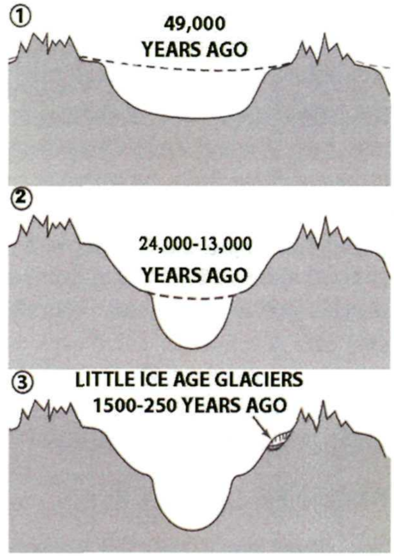
Horn - A pyramid-like peak formed where several cirques meet.

Moraine - Rock and other sediment carried and deposited by a glacier. Moraines can be found in front of, alongside, and within a glacier.

GLACIATION NEAR SKAGWAY

Glaciers have advanced and retreated through the Skagway area for millennia due to a series of cold intervals (Ice Ages) alternating with intervening warm periods.

Each subsequent period of glaciation removes the geologic record of the previous one. Evidence of only the two most recent periods of glaciation are visible today in the Skagway Valley.



Some 49,000 years ago glaciers filled the Skagway Valley up to the level of the craggy peaks, burdening the land with flowing ice over 5,000 feet thick. The ice ground down through the river's course and carved a steep-sided, broad **U-shaped valley**. In passing it polished any projections in the valley, leaving massive, rounded rock shoulders behind.

Between 13,000 and 24,000 years ago a smaller ice age occurred in this area. During this time glaciers carved a smaller U-shaped valley into the existing valley floor.

In very recent times during a period called the Little Ice Age, approximately 500 to 250 years ago, small glaciers formed at high altitudes. Harding Glacier, visible from downtown Skagway, is a remnant from this time.

Snow-capped nunataks

The highest peaks near Skagway are referred to as **nunataks**. A nunatak is an isolated hill or peak which projected through the surface of a glacier and was completely surrounded by ice or snow. As glaciers flowed over the landscape, they ground the contours beneath them smooth. The peaks above the ice escaped this grinding, leaving behind nunataks that maintain their original sharp and jagged appearance.

The Skagway Valley also includes a number of **hanging valleys**. These were formed when a large glacier, cutting a very deep valley, crossed the path of a smaller glacier. Since this glacier was not powerful enough to grind down into the mountains as deeply as the larger glacier, its valley floor stood much higher in elevation. While the glaciers were active, the mouth of the smaller one hung over the larger. An icefall, the glacial equivalent of a waterfall, emptied into the deeper valley below. After the glaciers melted, a small U-shaped valley at a high altitude remains and "hangs" over the landscape.

Not just the motion, but also the weight of glacial ice left its mark here. A river of ice 5,000 feet thick is quite heavy. Relative to the rest of the Earth, the crust is very thin. The weight of the glaciers depressed the crust into the mantle. Now relieved of that load, the crust is springing back in a process called **glacial rebound**. Due to uplift and rebound, Skagway rises about 0.76 inches each year. Thats about six feet since the gold rush.

GOLD AND SKAGWAY

KLONDIKE GOLD RUSH

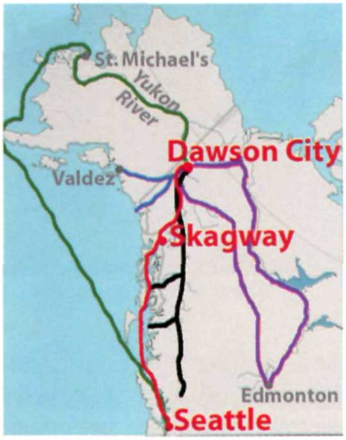
No gold was ever found in the Skagway Valley. The gold fields were located approximately 600 miles to the north, near the junction of the Klondike and Yukon Rivers at today's Dawson City. Skagway became internationally known solely as a gateway to the Klondike gold fields.

Promoters advertised many routes to the Klondike:

Purple - "All-Canadian" Route. Sold as a wagon route over flat prairie, it led instead 1,500 miles through unimproved wilderness.

Black - Ashcroft Route. Skirted the Canadian Rockies through an interior rainforest, that was almost impassable.

Blue - "All-American" Routes. Shortest routes to Klondike but led directly over glaciers. Dangers included crevasses, snow-blindness, starvation, and freezing due to lack of fuel for fires in the middle of the ice.



Routes north

Green - All-Water "Rich-Man's" Route. Steamships sailed around Alaska and 2,200 miles up the Yukon River. Easiest, most expensive route. Impassable for eight months a year when river was frozen.

Red - "Trail of '98." Steamship trip up Inside Passage to Skagway, followed by approximately 40-mile hike over Chilkoot or White Passes to Bennett Lake, source of Yukon River. Floated remaining 500 miles downriver to Dawson City.

Gold Rush **stampeders** used the Skagway area for the same reason rivers and glaciers did: it was a point of geologic weakness. The faults throughout the area allowed glaciers to carve more deeply here than elsewhere. As a result, the White and Chilkoot Passes had lower elevations and were passable year-round. They were the most used breaks in the Coast Mountains for hundreds of miles. Once over the passes it was a short journey down the Yukon River to Dawson City. Fast and cheap, this route attracted 90% of the Stampeders.

FORMATION OF GOLD

One way gold veins form is when magma pushes into solid rock. As magma cools and solidifies, superheated water and other substances, including gold, separate from the magma. The superheated liquid is under high pressure and can crack the surrounding solid rock, forming fissures, which the liquid travels through. As the liquid cools, solid material including quartz is deposited creating quartz veins. Any gold present solidifies inside the quartz veins.

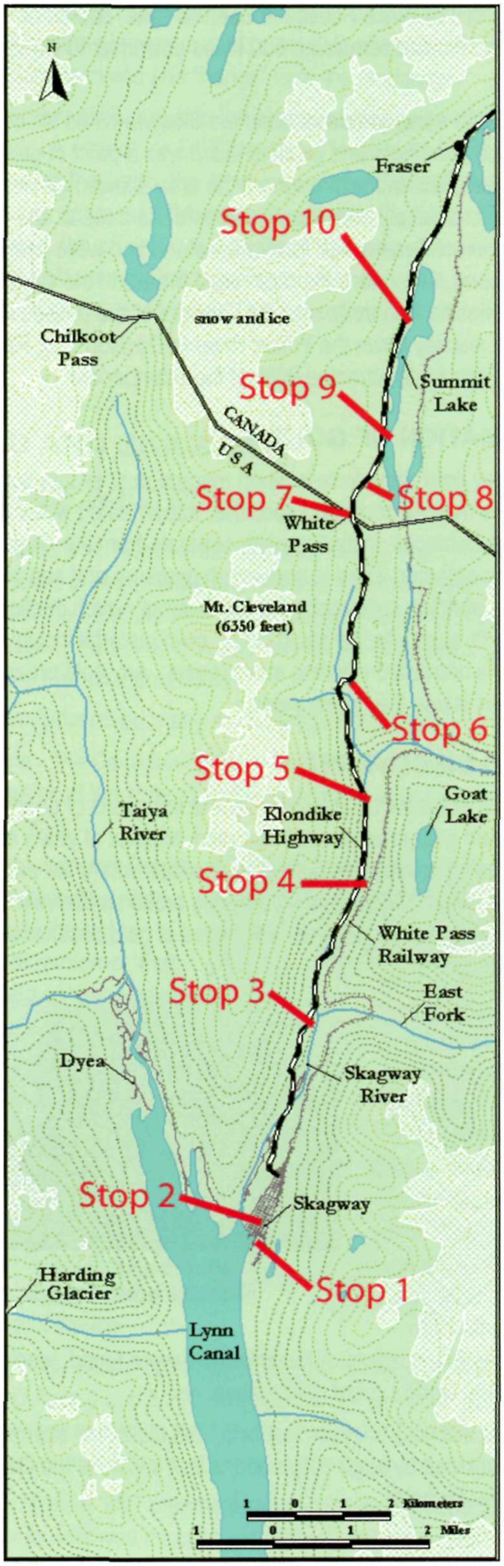
GOLD DISCOVERED

Beneath present-day Dawson City the intrusions of quartz contained a large amount of vein gold. Millions of years of uplift eventually exposed this gold to the surface where ice and rain could erode it. Millennia of weathering broke up the vein gold into smaller pieces: nuggets and flakes of gold dust known as **placer gold**.

The placer gold washed into the streams and creeks that feed the Klondike River. Many times heavier than sand and dirt, the gold sank to the bottoms of the creek beds. It collected there until 1896 when the first nuggets of Klondike gold were found, leading to one of the world's great gold rushes.


Miners displaying Klondike gold nuggets

There is still gold "in them thar hills," but individual stampeders were replaced by large corporations that still mine the Dawson City area for gold.



Route map

ROAD LOG

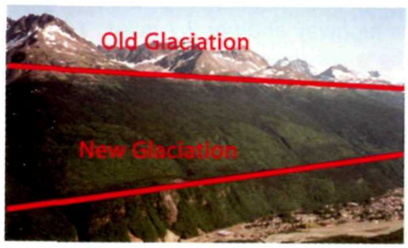
Evidence of these geologic forces abounds in the Skagway Valley, and the Klondike Highway provides an excellent way to view them. This road guide will introduce you to just a few of the geologic processes and features you can see in the area.

Your journey begins in the parking lot of the Alaska Marine Highway terminal, one block south of the National Park Visitor Center, and leads north out of Skagway on the highway for 18 miles (29 km). Terms that have been introduced earlier in this guide are in **bold**. Set your odometer to zero and get going!

STOP 1 - Ferry Terminal, mile 0.0 (km 0.0)

To the south across the Lynn Canal, the tiny Harding Glacier lies near the top of its mountain. One of the last glaciers remaining after thousands of years of glaciation in the Skagway area, Harding is not the only sign that glaciers were here. The modern appearance of the land is evidence of their passing. The Lynn Canal itself is one huge glacial valley. Now filled with water, at over 100 miles long and 1,700 feet deep, it's the longest and deepest **fjord** in North America.

The Skagway Valley and White Pass lead off to the north. The two most recent significant periods of glaciation are visible here. 22,000 years ago glaciers over 5,000 feet thick formed the great valley. 13,000 years ago a smaller episode carved a narrower valley into the existing one, less than 1,000 feet deep. Note the berms on either side of Skagway, which are sides of the newer valley.



Two levels of glaciation

Proceed up Broadway 6 blocks to 5th Ave. and mile 0.4.

STOP 2 - Broadway and 5th Ave. at mile 0.4 (km 0.6)

During the gold rush, the highest tides occasionally peaked here at 5th Avenue. Now this cross street is high and dry and prime real estate. Today the waterfront is farther back be-

High tide, Oct. 27, 1897

cause the processes of tectonic **uplift** and glacial **rebound** combine in Skagway to lift the land about 0.76 inches/year. This means that in the 100+ years since the gold rush, the land has risen over six feet.

Continue up Broadway until it ends at 15th Avenue. Go left one block, then right on State St. Continue up State St. to 22nd Avenue. Turn left onto the Klondike Highway. Proceed north until you reach the pullout at mile 5.0.

STOP 3 - Pullout at mile 5.0 (km 8.0)

Due east from here the East Fork of the Skagway River winds up away from the main channel. Note the profile of the valley – a classic **U-shaped** glacial feature. The East Fork is the site of a fault that was a conduit for glaciation. Up to the right the Twin Dewey Peaks reach 5,635 feet. Although the peaks are jagged **nunataks**, below about 5,000 feet the contours of the mountains are smoother, worn down by moving glaciers. The different appearance in the valley shows how deep the glaciers were. At the top of the valley, more than six miles away, sits South Glacier, the remnant of this great period of glaciation.

U-shaped valley

Continue north on the highway another 2.7 miles, 1 mile past US Customs. There are three pullouts in quick succession here – pull in at the third where there are wayside exhibits.

STOP 4 – 3rd pullout near mile 7.7 (km 12.3)

The valley below was carved more recently. The river carved this valley with less power but more speed than a glacier would, resulting in steep walls and a **V-shaped** profile.

Across the valley a pipe and waterfall descend from Goat Lake, currently the source of Skagway's hydroelectric power. Formerly, a glacier ended at Goat Lake leaving behind the **hanging valley** we see now.

V-shaped valley

The winter route of the White Pass Trail lies below. **Stampeders** pulled heavily laden sleds on the frozen river. Summer travel was more difficult, over crude roads cut out of the steep hillsides. Note the rugged peaks surrounding the road. This valley controlled access into the interior by gold seekers and others.

Proceed north a half mile to another pullout on the right.

Granite pluton

STOP 5 - Pullout at mile 8.2 (km 12.3)

Directly ahead is an example of a portion of a **pluton**. A magma chamber deep within the earth cooled slowly, forming this pluton. Through uplift and erosion, the pluton is now exposed to the sky as a uniform mass of granite. Through these processes and during its formation a pluton will be stressed and cracked, leaving behind open fractures called joints. Later on, magma intrusions may force superheated solutions, like those that deposit gold, into the joints. These then solidify as dikes. On the left side of the road here, superheated molten lava intruded into the granite, leaving behind dikes of dark basalt.

Basalt dikes

Proceed north 3.4 miles. This section of road passes through an avalanche area so DO NOT STOP anywhere before the Moore Bridge. Cross the bridge and stop at the first pullout on the right.

STOP 6 - Moore Bridge pullout at mile 11.6 (km 18.6)

The Moore Bridge just south of this pullout is one of only about a dozen in the world with this design. The bridge is cantilevered, so that only the south end is moored to the rocks while the north end just rests on the opposite side. This design is necessary because the bridge spans a fault. The river cascading through this chasm is exploiting a pre-existing line of weakness. Should any further movement occur along this fault, the bridge may detach from the north side, but it will not fall. Repairs will be minor ones reattaching the road bed as opposed to major ones rebuilding the entire bridge.

Moore Bridge

Follow the road north until it reaches its highest elevation. Stop at the paved pullout on the LEFT side of the road at mile 14.4.

STOP 7 – Left side pullout at mile 14.4 (km 23)

At 3,292 feet, this is the highest point on the Klondike Highway as well as the location of a sub-continental divide. The waters of the lake and creek visible to the south flow downwards about twenty miles to Taiya Inlet and the Gulf of Alaska. On the north side of this divide they flow down to the Yukon River and then 2,200 miles with it to empty into the Bering Sea.

Sub-continental Divide

A consequence of this area's continuing uplift is that between five and twenty-two million years ago the Coast Range mountains here were lower than at present. Waters flowed southeast into the ancestral Stikine River. The modern rise of the mountains tilted "downhill" to the north and forced them into the Yukon watershed. After another million years of erosion they may change course and flow south once again.

Continue north over the border into Canada. Stop at the first pullout on the right, just over a mile beyond.

STOP 8 – Pullout with outhouses at mile 15.6 (km 25.0)

Suddenly the horizon opens up. You have passed through the area of greatest uplift and rebound. While this area is currently more stable than the Skagway Valley, it was once the center of the action.

Valley at summit

Tens of thousands of years ago this was the site of an icefield, the zone of accumulation that fed all the glaciers flowing south. A sheet of ice a mile thick covered this great basin. As millennia of snowfall caused the ice sheet to grow and overflow the basin, rivers of ice escaped over the sides. Glaciers from the higher peaks also flowed in. All of this activity scraped the valley clean and flattened the landscape. Its high elevation has prevented vegetation from foresting the valley floor. The result is an otherworldly landscape - a "moonscape" - as raw and powerful a terrain as you are likely to see anywhere.

Drive north 0.6 miles to the gravel pullout at mile 16.3 by the red and white "Fraser Maintenance Section" sign.

STOP 9 - Gravel pullout at mile 16.2 (km 25.9)

At this stop, glaciers and many of the features of the glacial landscape are visible to the right. These include crevasses, moraines, cirques, and horns carved and chiseled out of the rock by the movement of the ice.

Glacial features

At the height of summer, when the snow has melted, the deep blue color of glacial ice is easy to see. The dense ice absorbs every other color of the light spectrum except blue, which alone reflects back to your eye.

Proceed north to a gravel pullout at mile 18.0, just before the bridge over Summit Creek.

STOP 10 - Gravel pullout at mile 18.0 (km 28.8)

Summit Lake below has a unique color as opposed to the lakes visible from the last stop. When glaciers grind through an area, they shape the land not only by carving off and moving large chunks of rock, but also by crushing materials in their path. The passage of the ice pulverizes these materials so finely that the remnants are called glacial silt or flour. When meltwater washes this flour into lakes, it is so light that instead of settling to the bottom of the lake it hangs there, suspended in the water. As a result, glacier-fed lakes have a milky blue-green color as opposed to rain- and runoff-fed lakes that are clearer.

Summit Lake

The road log ends here. You can drive north for an hour and a half to reach Whitehorse in the Yukon Territory or turn around and head back to Skagway. As you continue your travels through Alaska and northwest Canada, look for evidence of the colossal geologic forces at work in this part of the continent. Keep in mind that the route of these roads was dictated by the geology, diverting around an uplifted pluton or following a glaciated U-shaped valley. Understanding the processes that shaped the land makes viewing the fabulous scenery that much richer.

Geology, Glaciers, and Gold highlights the most common physical features and processes found in the area of Klondike Gold Rush National Historical Park.

Klondike Gold Rush NHP is headquartered in Skagway, Alaska, at the northernmost end of the Inside Passage.

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Cover photographs: Scenes of various geologic features around Skagway. (Top) Skagway Valley from above Lynn Canal; (center) the Meade Glacier near Skagway; (bottom) gold rush participants sluicing their pay dirt to separate out the gold.