BEDROCK

Three bedrock units are visible on the north side of and in Little Cottonwood Canyon:

Little Willow Formation

The Little Willow Formation weathers from a gray to a brown color.

Big Cottonwood Formation

The quartzite portion of the Big Cottonwood Formation is reddish-brown in color.

Little Cottonwood Stock

The Little Cottonwood Stock is light gray in color.

Metamorphic Rocks

Metamorphic rocks form from pre-existing rock that has been altered by heat, pressure, and/or chemical reactions in the Earth's crust.

Igneous Rocks

Igneous rocks form from the cooling and solidifying of molten rock.

Little Willow Formation

The Little Willow Formation is approximately 1.7 billion years old, making it the oldest rock in the Salt Lake City area. The highly metamorphosed rock consists primarily of intensely contorted quartz schist and gneiss intruded by igneous rocks that have been altered to amphibolite and chlorite schist.

The rock is mostly covered by vegetation and is difficult to see where it appears on the hillside to the north of the canyon.

Big Cottonwood Formation

One billion to 850 million years old, the Big Cottonwood Formation is a low-grade metamorphic rock that consists of reddish-brown quartzite and black to purple to green shale, argillite, and slate. Originally deposited along the shoreline of an ancient sea, ripple marks and mud cracks are still preserved in this rock.

The rock on the north canyon wall is easy to distinguish from the adjacent light-gray "granite" farther up the canyon.

Little Cottonwood Stock

This igneous rock is quartz monzonite, or more generally called granite. Between 32 and 31 million years ago, magma pushed up through the crust into overlying rock layers and then cooled and solidified before reaching the surface. Quartz monzonite is composed of plagioclase, quartz, orthoclase, biotite, and hornblende.

Popular for rock climbing, this light-gray granitic rock makes up most of the canyon walls.

Mines and Quarries

Mines: Little Cottonwood Canyon was a prosperous mining area in the late 1800s and early 1900s, during which several mining towns briefly flourished. Silver and lead were produced, with minor quantities of copper, zinc, and gold. Metallization in this canyon was caused by intrusions of hot magma. Heat from the magma drove mineral-rich fluids into surrounding rock, creating the ore deposits.

Small amounts of gold were mined from the Little Willow Formation on the slope to the north of the canyon mouth (several mine dumps are still visible). The town of Gold City, which included two mills and a mercantile company, appeared for a short time.

Workers cut stone blocks from Temple Quarry using sledgehammers and hand-held drill bits circa late 1800s. Photograph used with permission of the Utah State Historical Society, all rights reserved.

The engraved rock at the entrance to this View Park is from Temple Quarry and displays several drill holes.

The Temple Quarry Trail Park on the south side of the mouth of the canyon contains short walking trails and informative signs.

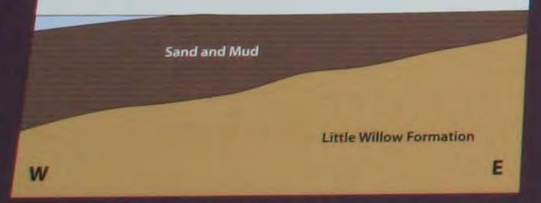
Quarries: At the mouth of the canyon, the granitic rock of the Little Cottonwood Stock has been quarried at various times since the 1860s to construct several prominent buildings in Salt Lake City including the LDS* temple and Utah's Capitol.

* The Church of Jesus Christ of Latter-day Saints

History of the rocks in this part of the Wasatch Range

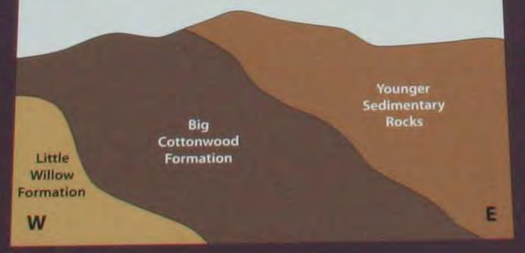
1 billion to 850 million years ago

Long after the Little Willow Formation was in place, sand and mud are deposited on top of that rock in a tidal-flat environment along an ocean shoreline. These sediments were later buried and compacted, cemented, and metamorphosed to become the Big Cottonwood Formation.



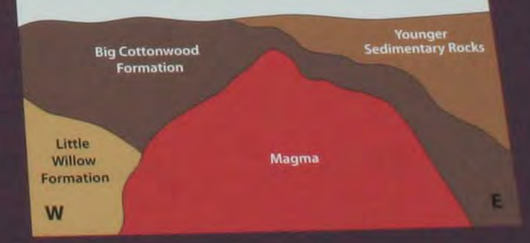
130 to 50 million years ago

After many different sediments were deposited, the Sevier orogeny (a mountain-building event) folds and tilts the sedimentary rock layers and the Little Willow and Big Cottonwood Formations.



32 to 31 million years ago

Magma (molten rock) rises into overlying rock layers. The magma cools and crystallizes while still beneath the surface to become the quartz monzonite of the Little Cottonwood Stock.



Past 17 million years

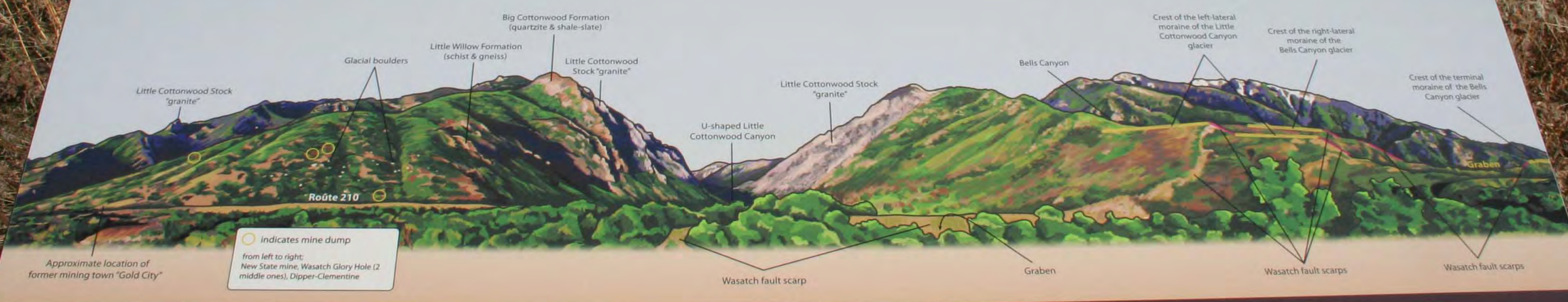
The Wasatch Range begins to rise along the Wasatch fault. Uplift and subsequent erosion of softer sedimentary rock layers uncovers the three rock units. Sediments shed off the rising mountains are transported into Salt Lake Valley. The deposited sediments are now thousands of feet thick.

G.K. GILBERT GEOLOGIC VIEW PARK

G.K. Gilbert

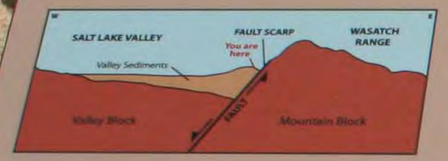
Grove Karl Gilbert (1843-1918) is considered one of the greatest American geologists, having pioneered many theories in the earth sciences. In the late 1800s and early 1900s, Gilbert advanced concepts on mountain building, fault scarps, earthquake probabilities, and lake cycles that have withstood the test of time and are still used today. Furthermore, Gilbert applied science toward promoting public welfare by advocating the need for evaluation of risks and public disclosure of geologic hazards.

Utah was one of Gilbert's favorite study areas where he formulated many of his theories He spent much time at this particular location and was the first to establish that Little Cottonwood Canyon and Bells Canyon glaciers descended as far as the shoreline of ancient Lake Bonneville. Gilbert was also the first person to recognize the earthquake hazard posed by the Wasatch fault.



THE WASATCH FAULT

You are standing by the Wasatch fault, one of the longest and most active faults of its type in the world. Movement along this fault can generate earthquakes as large as magnitude 7.5.



Normal fault

A fault is a break in the Earth's crust along which blocks of crust slip past each other. The Wasatch fault is called a "normal" fault where movement is mostly vertical. Here, the mountain block (Wasatch Range) moves upward relative to the adjacent downward-moving valley block (Salt Lake Valley). You are standing on the valley block.

Fault scarp

During a large (magnitude 6.5 – 7.5) earthquake, fault rupture can reach the surface and vertically displace the ground along the fault, creating a fault scarp (steep break in slope). Scarps caused by a single large earthquake can range in height from a fraction of an inch to over 10 feet. Here the scarps reach heights over 100 feet, meaning that many large earthquakes have occurred at this location.

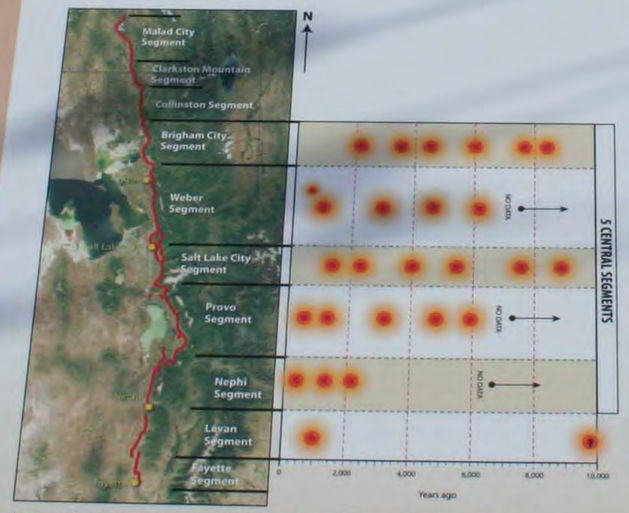
Zone of Deformation

The fault dividing the mountain range and the valley is seldom a single break, but rather a complex "zone of deformation" comprising many parallel faults and broken, tilted, and downdropped blocks of ground. The fault scarp in front of you breaks into several strands to your right (south) where multiple fault scarps cut across glacial moraines.

The land that is dropped between two opposing fault scarps is called a graben. In front of you, Wasatch Boulevard traverses through a graben, with the main fault scarp on the east side of the road and an opposite-facing fault scarp on the west side of the road.

Wasatch Fault Segments

The 240-mile-long Wasatch fault extends from Malad City, Idaho, to Fayette, Utah. The fault is divided into 10 segments, averaging 25 miles in length; each segment acts independently and is a separate source of large earthquakes.



Large earthquakes during the past 10,000 years on six segments of the Wasatch fault (data current to 2007). Imagery courtesy of NASA, Terra Satellite, MODIS Sensor, 2001.

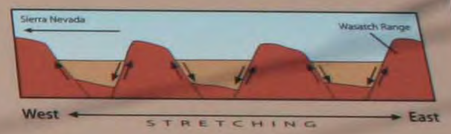
Number of Large Earthquakes on the Wasatch Fault

At least 27 large (magnitude 6.5 – 7.5) earthquakes have taken place on the Wasatch fault over the past 10,000 years. All but two of these earthquakes occurred on the five central segments of the fault between Brigham City and Nephi.

Timing of Large Earthquakes on the Five Central Segments

The average amount of time between large earthquakes occurring somewhere on one of these five segments is 300 to 400 years. The most recent large earthquake took place about 300 years ago on the Nephi segment. For any individual central segment, the average time between large earthquakes is longer - about 1,200 to 2,600 years. The time between large earthquakes on the less active segments at the ends of the Wasatch fault is 10,000 years or more.

Nobody knows when or where the next large earthquake on the Wasatch fault will take place. The prehistoric record suggests a future large earthquake is not a matter of "if," but "when."



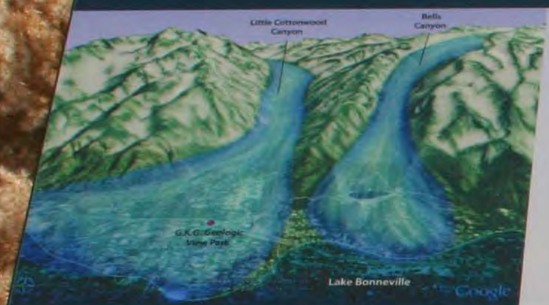
The Basin and Range Province

Approximately 17 million years ago, the area between Utah's Wasatch Range and California's Sierra Nevada began stretching in an east-west direction. The Earth's crust responds to this stretching by breaking and shifting along normal faults causing mountain ranges to rise and valleys to drop. The resulting topography forms the Basin and Range Province, so named for the alternating valley basins and mountain ranges characteristic of the region. The basins and ranges trend in a north-south direction.

Imagery courtesy of NASA, Terra Satellite, MODIS Sensor, 2001.

GLACIERS

When the climate was colder and wetter between 30,000 and 10,000 years ago, glaciers covered Utah's high mountains and plateaus. This time interval is often called the most recent, or the last Ice Age.



These glaciers extended into Lake Bonneville. This is one of the few localities in the world where mid-latitude alpine glaciers met lakes during the last Ice Age.

How thick was the Little Cottonwood Canyon glacier?

The highest elevation of the glacial boulders, the moraine crests, and erosional features in the canyon indicate that the glacier was about 450 feet thick at the canyon mouth. In the upper canyon, the glacier was as much as 850 feet thick.

Why is there no terminal moraine from the Little Cottonwood Canyon glacier?

The terminal moraine was probably either eroded by streams from the melting glacier or buried by sediment deposited by the streams when the glacier started to retreat.

Moraines

Linear rocky ridges deposited as ice containing rocks melts on the sides (lateral moraines) and end (terminal moraine) of a glacier.

The Advances and Retreats of Glaciers

Of the 60 glaciers that once existed in the Wasatch Range, only a few flowed beyond the mouths of the canyons into adjacent valleys; the most prominent were in Little Cottonwood and Bells Canyons.At 12 miles long and as much as 850 feet deep, the Little Cottonwood glacier was the longest and largest in the Wasatch Range.

Glaciers retreat and advance in response to climate fluctuations. Several glacial advances from Bells and Little Cottonwood Canyons occurred between 16,500 and 13,500 years ago when the air temperature was about 12°F colder than today. The climate then warmed and the glaciers eventually melted.

Glaciers Change the Landscape

The landscape here and farther up the canyons has been greatly altered by glaciers.

A glacier is a moving mass of ice and snow. Glaciers flowing down a valley, or canyon, scour and pluck rock from the canyon's floor and walls. These rocks become embedded in the ice, which further adds to the erosive power of a glacier. Also, rocks from rock fall are carried on top of the ice. When the ice melts, the rocks carried in and on top of the ice are deposited in moraines or erratically strewn about.

The retreating Woodworth glacier in Alaska illustrates how glaciers dramatically sculpt the landscape.

Image courtesy Bruce Molnia, Terra Photographics; Image source: Earth Science World Image Bank http://www.earthscienceworld.org/images

Aerial view of the canyons and glacial moraines. The left-lateral moraine of the Little Cottonwood Canyon glacier is fractured in several places due to movement of the Wasatch fault. Photo courtesy W. Kenneth Hamblin.

Arêtes

Sharp knife-edged ridges formed by glacial erosion between two adjacent U-shaped glacial canyons or cirques.

Cirques

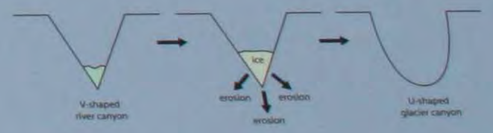
Large amphitheaters carved into the heads of glacial canyons.

Glacial Boulders

Large rocks or boulders carried by a glacier down from the higher reaches of the canyon. Here, the glacial boulders are the light-colored granitic rock (from the Little Cottonwood Stock that makes up the canyon's walls) seen all around you.

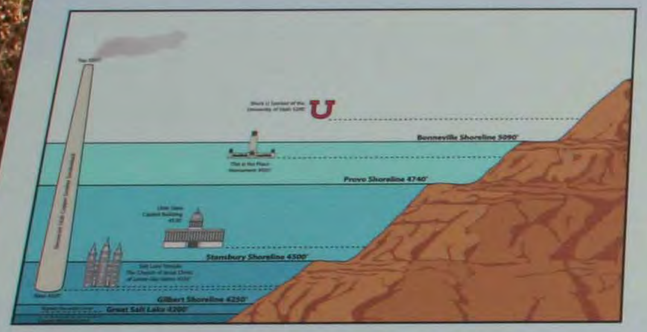
U-Shaped Canyon

One of the most distinctive features of a glacially scoured canyon is a wide U-shaped profile. A river in steep terrain erodes primarily downward resulting in a deep and narrow V-shaped canyon, whereas the heavy mass and large volume of a glacier scours the canyon floor and sides resulting in a much wider canyon base.

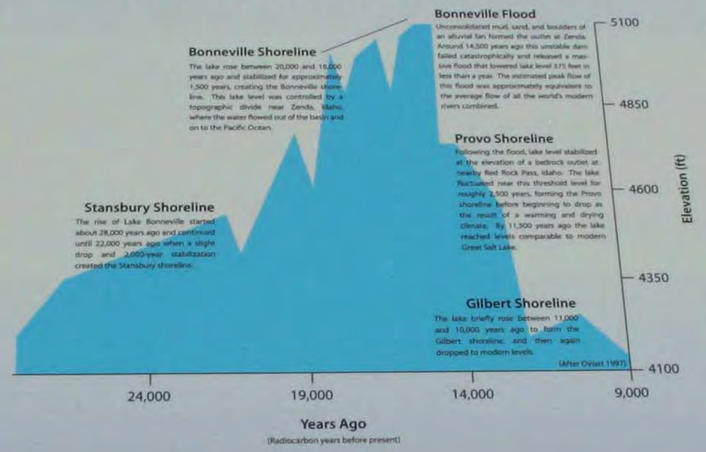


LAKE BONNEVILLE

At this site 15,000 years ago you would have heard waves crashing on the beach of Lake Bonneville 1/3 mile to the west. From this beach you could have sailed to Idaho, Nevada, or within 30 miles of Cedar City, Utah. Around that time, the freshwater lake had reached its maximum size, covering an area of almost 20,000 square miles. It was about 325 miles long, 135 miles wide, and over 1000 feet deep. Lake Bonneville was one of many lakes in western Utah and Nevada created by the colder and wetter climate during the last Ice Age.



The Rise and Fall of Lake Bonneville



Lake Bonneville and Climate

Internal Drainage

Most streams ultimately drain into the ocean. In the Bonneville basin, encompassing the western part of Utah, streams terminate at the lowest elevations possible – such as Great Salt Lake. Called a "closed basin," the Bonneville basin is an area with no stream outlet and hence is similar to a plugged bathtub. The only way water exits the basin is by evaporating. Consequently, evaporation (mainly controlled by temperature) and precipitation in the basin directly influence lake levels.

During Ice Age times, air temperatures averaged 10-15ºF colder than today. Cooler temperatures, especially during the summer, caused much less water to evaporate. More water entered the lake from streams than could leave by evaporation, causing waters to rise to the level where it filled the bathtub.

Lake Effect

Cool temperatures and resulting low rates of evaporation contributed to rising lake levels, but increased local precipitation probably also occurred through the Ice Age. This was in part due to a weather process known as "lake effect." Warm lake water destabilizes colder winter air moving over the lake. Snowstorm bands are generated downwind, enhancing snowfall totals. Several feet of snow can fall in the mountains from single lake-effect storms.

Today, up to ten percent of the annual precipitation in the Salt Lake Valley can be attributed to lake effect. During Lake Bonneville time, this effect was likely multiplied due to the lake's enormous size. Thus, more snow fell in the mountains, promoting the growth of glaciers.

Lake Bonneville's Shorelines

Like rings around a bathtub, shorelines are the most prominent vestiges of Lake Bonneville. Shoreline features include beaches, deltas, wave-cut benches, and spits and bars. Many of these shoreline features are major sources of sand and gravel used for construction projects.

Lake Bonneville Beaches

Lake Bonneville beaches range from sandy to gravelly. Ten miles southwest of this park, white sand beaches near Point of the Mountain are now covered with homes and vegetation. A major bar and spit complex near I-15 continues to be mined away in sand and gravel pits.

Bars and Spits

Bars and spits are major Lake Bonneville shoreline features. Bars are elongated ridges of sand or gravel formed offshore by lake currents. A bar attached to the mainland is called a spit. One of the world's largest, if not the largest, lake bar is the Stockton Bar located 30 miles west of this park. The Stockton Bar is actually made up of several sandbars and spits built upon one another.

Wave-Cut Benches

This wave-cut bench is located near Lucin, Utah, approximately 130 miles to the northwest. Strong waves eroded away the hard rock slope to form the bench.

Deltas

Deltas formed where rivers entered the lake and deposited the sediment they were carrying. This Provo-level delta extends from the canyon mouth in Brigham City, which is approximately 65 miles to the north. The delta is dissected by the modern stream.

At this park, glacial deposits obscure the Little Cottonwood delta.