

Excerpt from

# Geologic Trips, Sierra Nevada

by Ted Konigsmark

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## Trip 5. NORTHERN SIERRA

10 Miles

① Donner Pass

② Gold Run

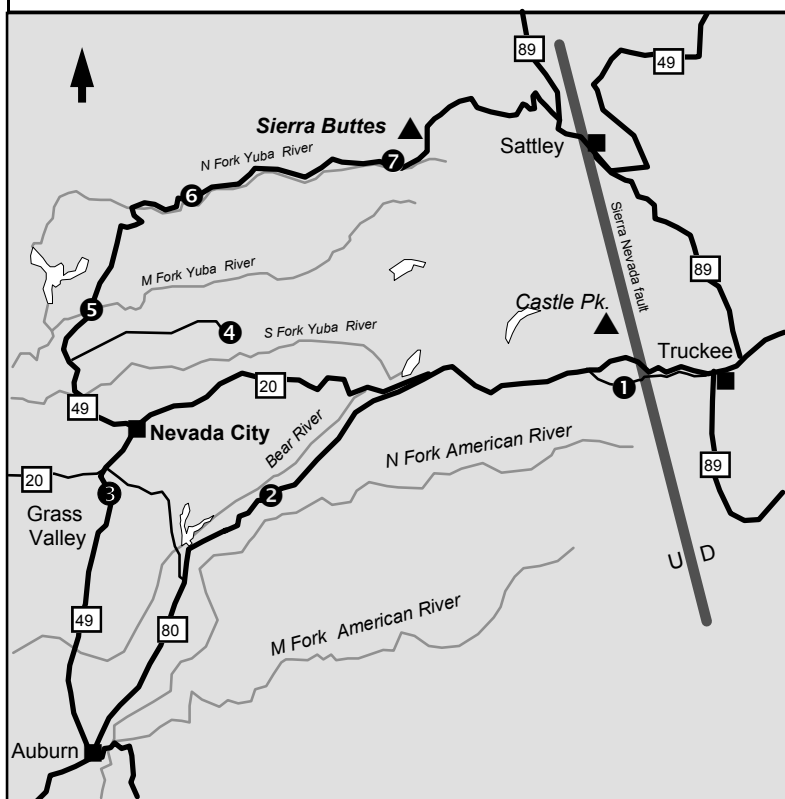
③ Grass Valley

④ Malakoff Diggins

⑤ Yuba River

⑥ Goodyears Bar

⑦ Sierra City



## Trip 5

# NORTHERN SIERRA

### *Tertiary Sedimentary and Volcanic Rocks*

Geologically, the northern Sierra differs from the central and southern Sierra in several ways. Most importantly, the northern Sierra is not as high. It was uplifted only about 5,000 feet during the Plio-Pleistocene compared to more than 10,000 feet of uplift in the southern Sierra. Due to the smaller uplift, the river valleys in the northern Sierra are not as deep and the Tertiary rocks have been preserved over large areas.

The Western Metamorphic Belt is also wider and more complex in the northern Sierra and contains several metamorphic rock units that do not occur in the central Sierra. These units, which include the Smartville Complex, Feather River Belt, and Northern Sierra Terrane, provide critical information about the geologic history of the Sierra Nevada and about the development of the western margin of North America during Paleozoic and Mesozoic time.

The gold belt in the northern Sierra is also different. The Mother Lode does not extend into the northern Sierra. Instead, the gold belt in the northern Sierra is wider and the gold occurs under more varied geologic conditions. The northern Sierra also had the largest hydraulic gold mining operations of the entire gold belt. Most of the hydraulic gold was mined from gravel that was deposited by the Eocene Yuba River. These Eocene river gravels are thick and widespread in the northern Sierra, and are not present at all in the southern Sierra. The northern Sierra also has the largest lode mine of the Sierra gold belt, the Empire Mine at Grass Valley. Other important lode mining areas in the northern Sierra include Nevada City, Allegheny, and the Sierra Buttes.

During the trip to the northern Sierra, you will see the Eocene erosion surface and some of the Tertiary sedimentary and volcanic rocks that were deposited on the Eocene surface. You will also see some of the rocks of the Western Metamorphic Belt that are unique to the northern Sierra and visit the largest hydraulic mine and the largest lode mine in the Sierra Nevada gold belt.

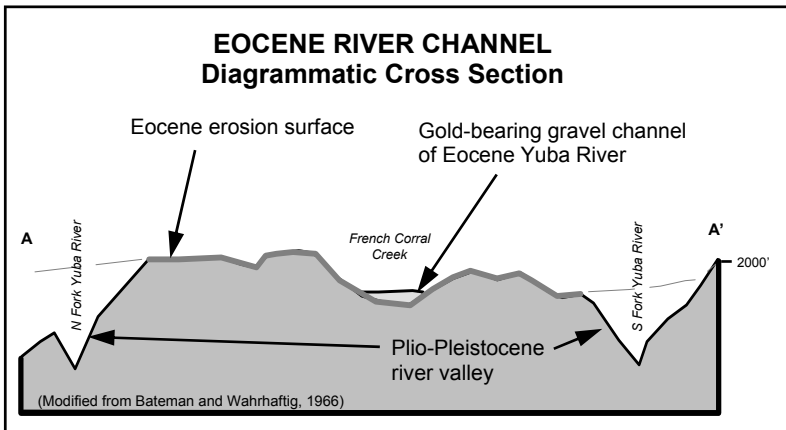
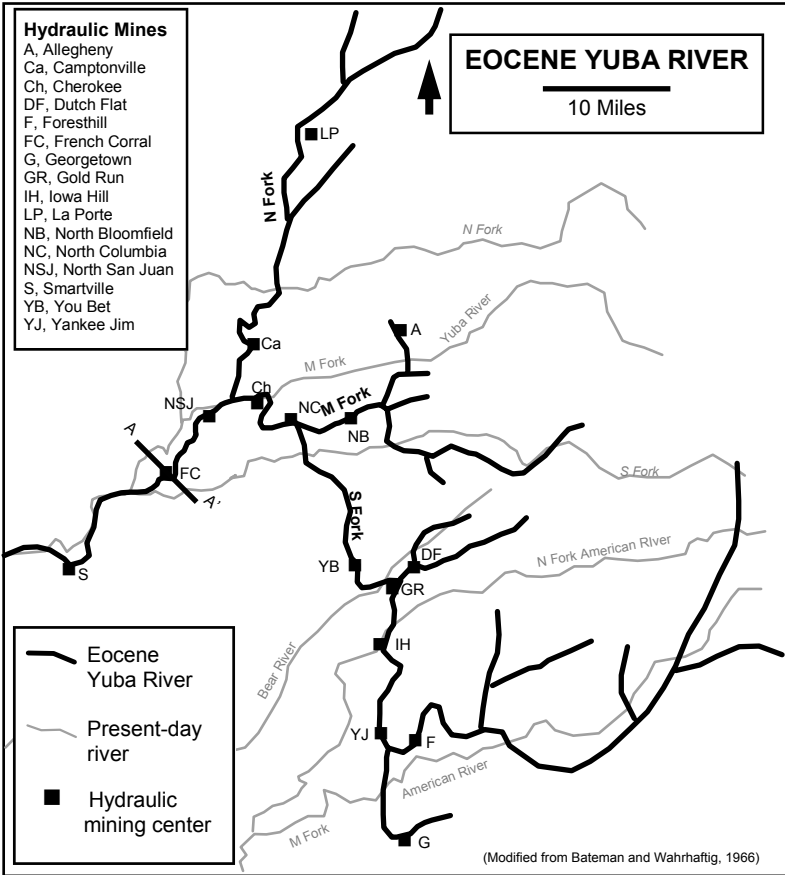
### **The Eocene Yuba River**

If you had flown over the northern Sierra in Eocene time, you would have been impressed by the size of the Eocene Yuba River. The river was much larger than the present-day Yuba River and extended far into Nevada as it drained the low rolling hills of the Eocene erosion surface. The channels of the Eocene river were broad, and the central parts were filled with gravel up to several hundred feet thick.

The accompanying map shows the extent of the Eocene Yuba River. The south fork began east of Foresthill, then went through Yankee Jim, Iowa Hill, Gold Run, You Bet, and joined the middle fork at North Columbia. The north fork began north of La Porte, then passed through Camptonville and joined the central fork east of North San Juan. The middle fork began near Allegheny, then went through North Bloomfield and joined the south fork at North Columbia. From North Columbia, the middle fork flowed through Cherokee and joined the north fork west of Cherokee. The river then flowed through North San Juan, French Corral and Smartville, and into the ocean in the Great Valley.

All three forks of the Eocene Yuba River carried gold, and gold has been mined from Eocene river gravels in all of the above localities. Most of this mining was hydraulic. The gold had come from the gold-bearing veins of the Sierra gold belt and had been concentrated on the Eocene erosion surface during millions of years of weathering. The gold was heavy and indestructible, so most of the gold stayed near the veins until it was swept into the Eocene river. The gold-bearing central channel came to be known as the *blue lead* due to the characteristic blue color of the gravel in the channel. The Eocene river gravel can be seen at a number of places in the Sierra. Two of the best places are at Gold Run on I-80 and at the Malakoff Diggins near North Bloomfield.

This picturesque river setting ended in Oligocene time, when volcanoes began to erupt the huge quantities of volcanic ash of the Valley Springs Formation. The ash rapidly covered the Eocene river gravels and filled the river valleys. Volcanism continued through Miocene time with deposition of the Mehrten Formation, forming a blanket of volcanic rocks over the entire landscape. As the volcanic rocks were deposited, old river courses were filled-in and new river courses were established. Some of the new rivers also contained gold, but only where these rivers cut through gold-bearing Eocene river gravel and picked up the gold from the Eocene gravel.



## **Interstate 80**

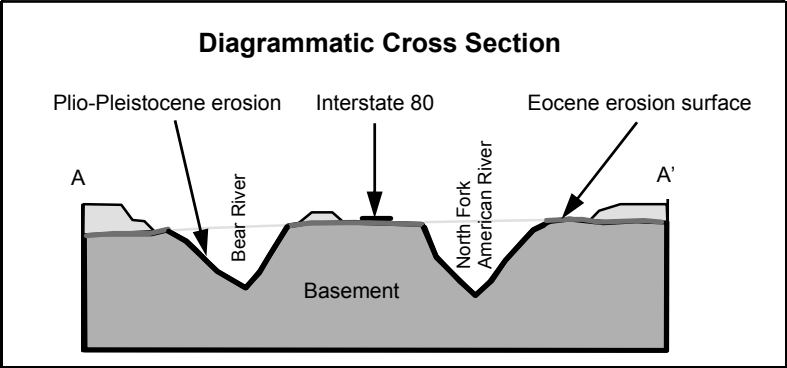
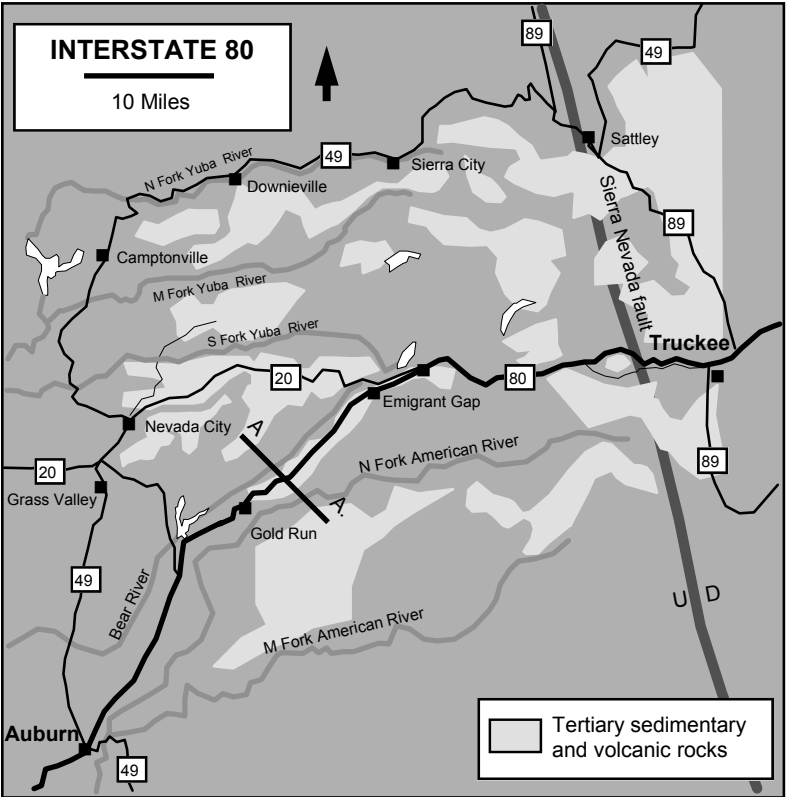
Between Sacramento and Reno, I-80 crosses the Sierra Nevada using Donner Pass. This is the lowest, easiest, and busiest path across the Sierra Nevada. It was used by early Native Americans and by early explorers, pioneers, and gold miners. Later, it was used by the railroad and Highway 40, and now I-80. All of the millions of people who have used this route across the Sierra owe their thanks to the geology of the mountain range.

Most of the major passes across the Sierra Nevada follow deep and torturous river valleys on their way across the Sierra crest. Not so for I-80. From Auburn to Emigrant Gap I-80 stays out of river valleys. Instead, the highway follows the drainage divide between the Bear River and the North Fork of the American River. This flat drainage divide is a remnant of the low rolling Eocene erosion surface that extended over the Sierra during Eocene time. Most of Tertiary sedimentary and volcanic rocks have been eroded from the divide, so the Eocene erosion surface now forms a convenient ramp that goes up the west flank of the Sierra. Since the Eocene erosion surface was formed near sea level, the present incline of the ramp closely reflects the amount of westward tilting of the Sierra during the Plio-Pleistocene uplift.

The Eocene erosion surface can be easily identified by the thick red soil that was formed on the surface during the long humid period of Eocene erosion. This red soil can be seen in many of the roadcuts between Auburn and Emigrant Gap. Near Gold Run, the highway passes through a river channel that was cut into the Eocene erosion surface by the Eocene Yuba River. The gravel that was deposited in this river channel is exposed in the large roadcuts of red gravel along the highway in this area.

The American and Bear rivers have cut deep valleys into the Eocene erosion surface on each side of the drainage divide. To appreciate how far the present-day rivers have cut into the Eocene erosion surface, take the short trip on Highway 49 from Auburn to the south. At Auburn, Highway 49 leaves the Eocene erosion surface and abruptly descends into the steep valley of the North Fork of the American River. Most of the erosion of the valley of the American River occurred during the Plio-Pleistocene uplift and tilting of the Sierra block.

I-80 uses the Eocene erosion surface as a geological bridge across the western slope of the Sierra. Thanks to the long period of Eocene erosion, you can cross the Sierra in comfort at highway speed in less than two hours. You can't do that on any other Sierra pass!



### ① **Donner Pass**

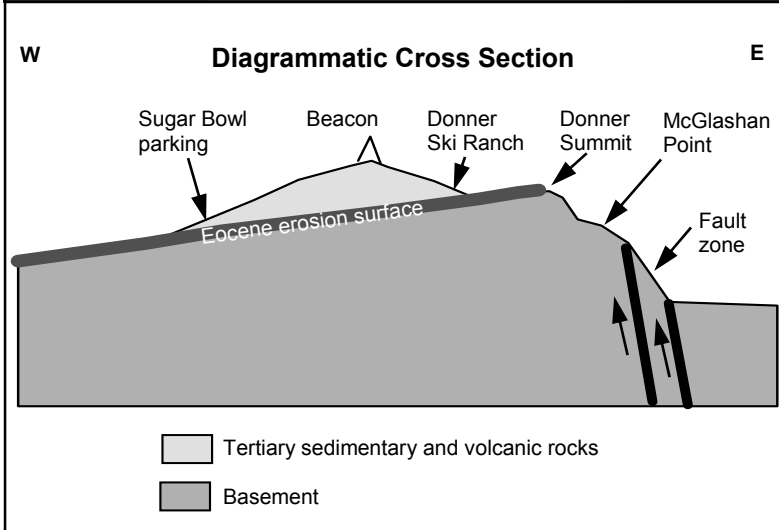
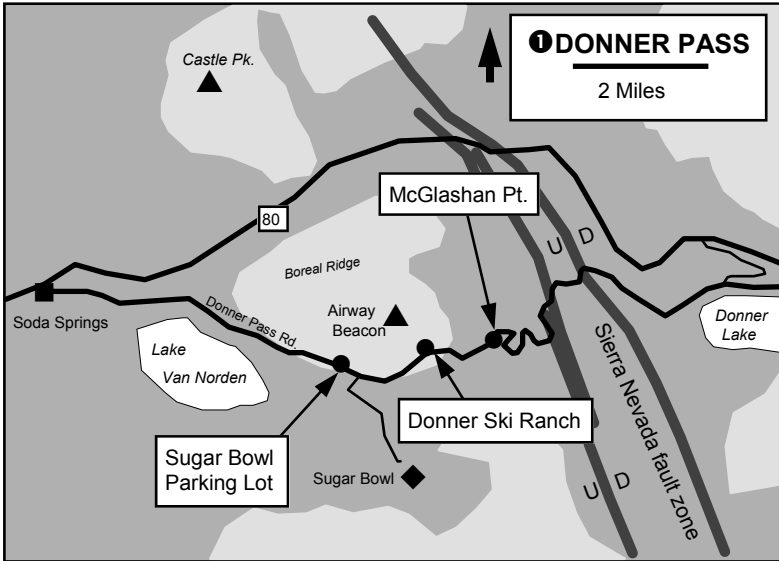
The best place to see the geology of Donner Pass is along the old Donner Pass Road from Donner Lake to Soda Springs. This road leaves busy I-80 at Donner Lake and rejoins I-80 at Soda Springs, and allows for a more leisurely look at the rocks and scenery along this historic pass. From Donner Lake, Donner Lake Road climbs up the granitic rocks of the steep eastern escarpment of the Sierra Nevada block. This escarpment was formed by faulting along the Sierra Nevada fault zone as the Sierra Nevada block was uplifted several thousand feet during the last five million years. At the summit of Donner Pass, the highway passes over the top of the tilted fault block and then descends gently along the top of the west-tilted fault block.

Several million years ago, prior to uplift of the Sierra, the top of the fault block was covered by thick Tertiary sedimentary and volcanic rocks. During uplift, most of these soft Tertiary rocks were eroded and removed from the top of the block. However, patches of the Tertiary rocks remain, mainly along drainage divides where erosion has not yet reached the rocks. From Donner Ski Ranch to the Sugar Bowl parking area, Donner Pass Road skirts along the southern edge of one of these remnants of Tertiary rocks. Donner Ski Ranch and the Sugar Bowl parking lot are good areas to see these Tertiary rocks.



Springtime view looking west from ice-covered Donner Lake. The steep escarpment of the Sierra Nevada was formed by 1,800 feet of uplift along the Sierra Nevada fault zone.





Donner Lake is named for the Donner Party, which camped at the lake during the winter of 1846-47 after being stopped by early snow. During that winter, the snow was 22 feet deep at this locality. Of the original party of 89, 42 perished. Donner Memorial State Park, on Donner Pass Road, at the east end of Donner Lake, is at the site of the camp. The park includes a visitor center, monument, campground and trails (530-582-7892 or [www.parks.ca.gov](http://www.parks.ca.gov)).

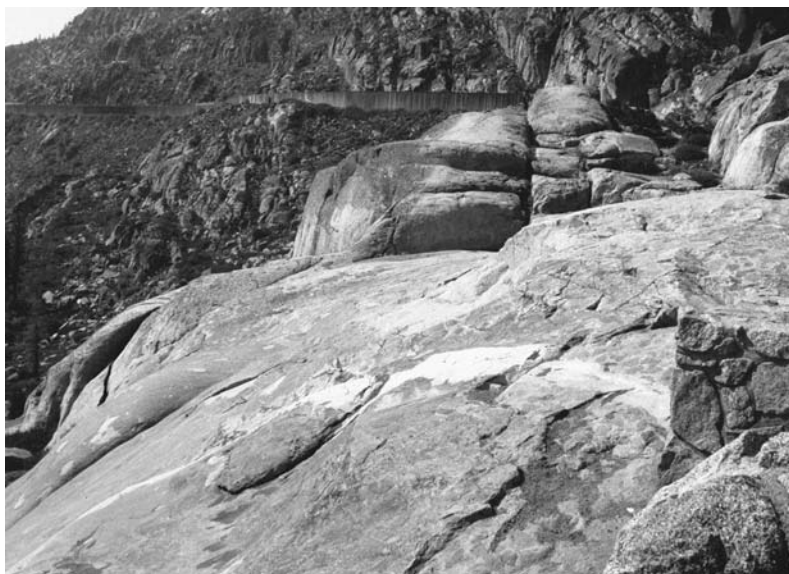
**McGlashan Point** - *From the Donner State Park exit on I-80 drive W on Donner Pass Rd. 6 mi.; turn right at the "Vista Point" sign for the McGlashan Point parking area; walk to the SE end of the overlook wall.*

McGlashan Point is near the top of the steep eastern escarpment of the Sierra Nevada, about 1,000 feet above Donner Lake. This escarpment was formed by faulting along the Sierra Nevada fault zone. The Sierra Nevada was uplifted an estimated 1,800 feet along the fault zone, which lies between McGlashan Point and Donner Lake.

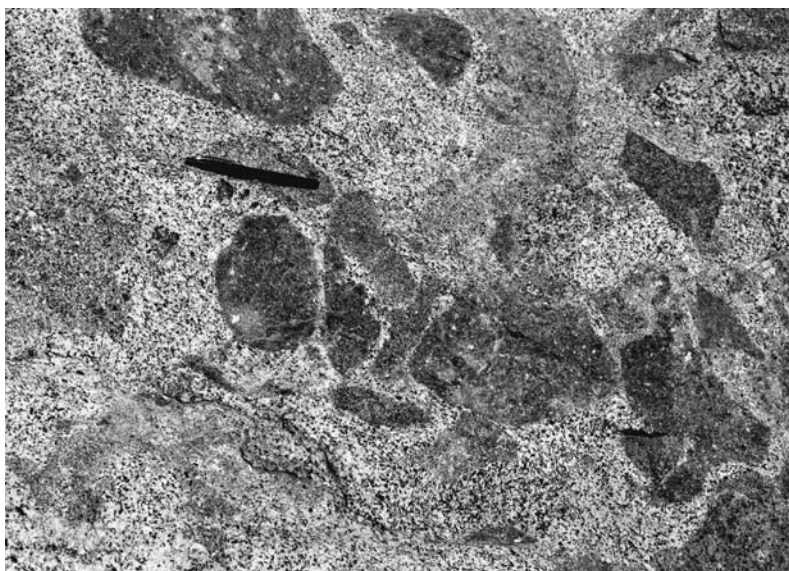
Looking east from McGlashan Point you can see down the U-shaped glacial valley of the Truckee River. During Pleistocene time, glaciers flowed off the steep eastern slope of Donner Pass and then eastward down this river valley. From here, you can see the lateral moraines that were formed by these glaciers on both sides of the valley, and the recessional moraine that forms the dam at the east end of Donner Lake.

The granitic rocks of the Sierra Nevada batholith are well exposed at McGlashan Point, where they were cleaned and polished by the glaciers moving down from Donner Pass. Most of these rocks are granodiorite of mid-Cretaceous age. The granodiorite has many xenoliths, almost giving it the appearance of a boulder conglomerate. The xenoliths probably represent pieces of roof rock that fell into the hot magma and were incorporated into the granodiorite. Judging from the large number of xenoliths, these granodiorites were probably near the top of the magma chamber, and erosion has not cut deeply into this pluton. Xenoliths may also form by segregation of dark minerals in the magma or by intrusion of a mafic magma into a granitic magma.

The granodiorite near the observation area is cut by a white alaskite dike. The dike has the appearance of a white ribbon running down the slope below the overlook. Alaskite consists almost solely of feldspar and quartz and is very hard. It probably represents the last of the magma in the magma chamber and was intruded into granodiorite that had already crystallized. The alaskite is more resistant to weathering than the granodiorite, so the glacial polish is well-preserved on the alaskite dike.



The white alaskite dike in the center of the outcrop cuts through granodiorite at McGlashan Point.



The granodiorite at McGlashan Point has many dark xenoliths. These are probably pieces of roof rock that fell into the granodiorite magma. Note the pen for scale.

**Donner Ski Ranch** - *Donner Ski Ranch is on Donner Pass Rd. immediately W of Donner Pass.*

The granitic rocks of the Sierra Nevada batholith are exposed at the summit of Donner Pass. Just west of the pass, there is a small hill at the Donner Ski Ranch. The hill has a ski lift and there is an airway beacon at the top of the hill. This hill consists of Tertiary sedimentary and volcanic rocks. These rocks are an erosional remnant of the Tertiary sedimentary and volcanic rocks that once covered the entire northern Sierra Nevada. These Tertiary rocks now sit on top of the granitic rocks of the Sierra batholith like a cupcake on a tilted plate.

The rocks in the lower half of the hill are mainly light-colored tuffs of the Oligocene Valley Springs Formation. We'll see more of these rocks at the Sugar Bowl parking lot. The upper half of the hill consists mainly of andesitic volcanic rocks of the Miocene Mehrten Formation.

The sedimentary and volcanic rocks that make up the hill are layered, and the layers dip gently to the west. This west dip is best seen by following the dark ledge of volcanic rocks in the center of the hill. When deposited, these rocks were near-horizontal. The rocks were tilted westward during uplift of the Sierra Nevada block, and conveniently record the amount of tilting of the Sierra block in this area.



This small hill at Donner Ski Ranch is an erosional remnant of the Tertiary sedimentary and volcanic rocks that once covered the central and northern Sierra.

**Sugar Bowl Parking Lot** - From Donner Pass, drive 1 mi. W on Donner Pass Rd. to the large Sugar Bowl parking lot on the N side of the highway.

The Sugar Bowl parking lot is cut into the light-colored rhyolitic tuffs of the Oligocene Valley Springs Formation. These tuffs were deposited as ash flows and ash falls and once covered much of the northern and central Sierra Nevada and extended eastward into Nevada, where they reached a maximum thickness of 4,000 feet near Pyramid Lake. Throughout the northern and central Sierra, the tuffs formed a thick blanket over the Eocene erosion surface and filled the river valleys that had been cut into the Eocene surface. As the old river valleys were filled by tuff, new river courses were established on the new blanket of tuff. The new rivers also drained west, but did not follow the old river valleys.

By mid-Pliocene time, the rhyolitic tuffs of the Valley Springs Formation and the overlying andesitic volcanic rocks of the Mehrten Formation had accumulated to a thickness of several hundred to several thousand feet over much of the central and northern Sierra Nevada. As the Sierra Nevada was uplifted during Plio-Pleistocene time, most of these soft sedimentary and volcanic rocks were rapidly eroded from the Eocene erosion surface. The rocks at the Sugar Bowl parking lot are a small remnant of this once-extensive blanket of Tertiary rocks.



The light-colored rhyolitic tuffs of the Valley Springs Formation at the Sugar Bowl parking lot record a major period of volcanic activity during Oligocene time. At one time these tuffs completely covered northern and central Sierra.

## ② Gold Run

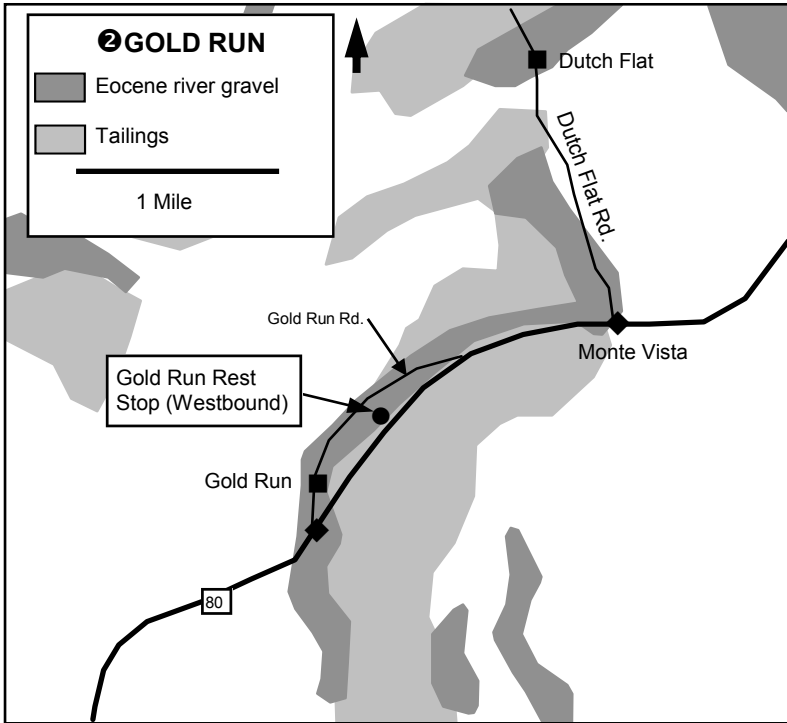
From 1860 to 1880, the town of Gold Run was the center of a major hydraulic gold-mining operation. The gold was removed from gravel that had been deposited in the South Fork of the Eocene Yuba River. The river channel at Gold Run was about a mile wide and 300 feet thick. This river probably had its headwaters in Nevada, and generally flowed westward and northward as it drained the low Eocene hills. The river channel at Gold Run had come north from Iowa Hill. After passing through Gold Run, the river turned northwest toward North Columbia, where it joined the Middle Fork of the river and flowed west into the ocean near Marysville. During the Plio-Pleistocene uplift of the Sierra Nevada, the rejuvenated rivers cut deeply into the old Sierra landscape and Eocene river system. Thus, the Eocene river gravels are now found only in isolated patches, mainly on divides between the present-day rivers. Gold Run lies on one of these drainage divides.

**Gold Run Rest Stop (Westbound)** - From the Monte Vista exit drive 1 mi. W on I-80 to the Gold Run rest stop on the north side of I-80.

The roadcuts along I-80 between the Monte Vista and Gold Run highway exits expose thick layers of red Eocene river gravel. To see this gravel, it is best to get off of I-80. One of the best places to do this is at the Gold Run rest stop on the north side of I-80 westbound. The rest stop is at the site of the old Stewart Mine, one of the major hydraulic gold mining pits in the Gold Run area. From the eastern end of the rest stop you can take a short trail to the working face of the Stewart Mine where there is a monitor in place poised for action. This mine was in operation from 1865 to 1878.

To recover the gold, the miners hosed out the gravel from the channel with powerful jets of water. The water was piped from an uphill location and then carried into the monitors that sprayed the hillside under tremendous pressure. The gold-bearing gravels were then washed through sluices and riffles charged with mercury where the gold was separated.

The gravels exposed at Gold Run are from the upper part of the Eocene river channel. Although these gravels contain some gold, they are not rich. Most of the rich gold was in the coarse gravel in the lower part of the channel. The boulders were mainly greenstone, phyllite, slate, and granodiorite, and some of the boulders were up to several feet in diameter. The rich, coarse, lower unit is called the *blue gravel* or *blue lead*. The gold in the blue lead averaged several dollars per yard. Not surprisingly, all of the blue gravel is now gone.



Eocene river gravels are exposed in the large roadcuts near the Gold Run rest stop on I-80. From 1865 to 1878 the Gold Run area was the site of extensive hydraulic mining of these gold-bearing river gravels.

### ③ **Grass Valley**

For many years, Grass Valley was the richest and most famous gold-mining district in all of California. Most of the gold from this area was produced from lode mines with extensive underground workings. The largest of these operations was the Empire-North Star Mine. Other important mines included the Old Brunswick, New Brunswick, Idaho, and Eureka. There was even a mine in the heart of the business district of Grass Valley, fittingly called the Golden Center Mine. By 1956, the Grass Valley area had an estimated 367 underground mines.

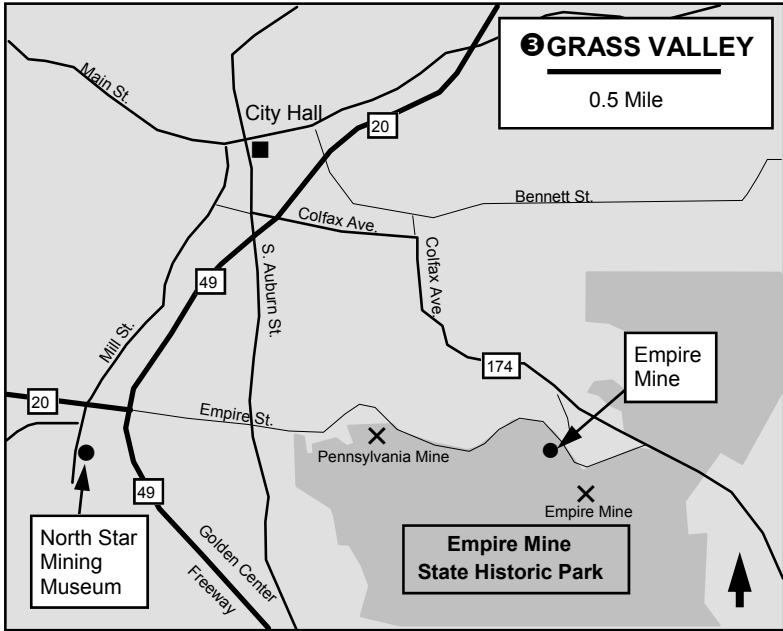
Grass Valley began as a small placer mining settlement in 1849. In 1850, a lump of quartz with gold was discovered. This discovery was quickly followed by quartz-gold discoveries at Ophir, Rich, and Massachusetts Hills. By 1851 Grass Valley was a boomtown with over 150 wooden structures. The surface placers were rapidly exhausted and most of the new discoveries were lode deposits. Lode mining was difficult and expensive, and large companies were needed to carry out the operation. These companies combined many of the smaller claims to facilitate development. In order to get experienced miners who would work at low wages under difficult underground mining conditions, they hired Cornish miners from the tin mines of Cornwall, England. The tin mines at Cornwall were nearly depleted, and the Cornish miners needed jobs. The Cornish miners have left their mark on the Grass Valley community in many ways, including a local specialty, Cornish meat pies called pasties. The pasties were carried in a tin box, heated by a candle, and eaten by the miners during their half-hour lunch break. The durable crust enabled the miner to eat the pastie easily by hand.

Most of the gold at Grass Valley occurs in quartz veins that cut igneous and metamorphic rocks of the Western Metamorphic Belt. Some of the ore-bearing quartz veins are in granodiorite, and some occur in greenstone, amphibolite schist, and serpentine.

**North Star Mining Museum:** *The North Star Mining Museum is at the S end of Mill St. (530-273-4255).*

The North Star Mining Museum occupies the old powerhouse for the North Star Mine. The museum has many mining displays, including pumps, a stamp mill, and other tools. The most impressive item on display, however, is the large Pelton water wheel. This wheel, which is 30 feet in diameter, was used to power an air compressor. The compressed air powered hoists, drills, pumps and other mining machinery. Pelton water wheels were used in many mining operations in the northern Sierra.





The North Star Mining Museum in Grass Valley is situated in the old powerhouse for North Star Mine.

**Empire Mine** – *The Empire Mine State Historic Park is at 10791 E. Empire St. (530-273-8522).*

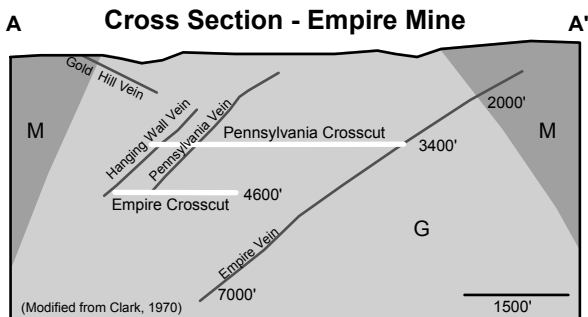
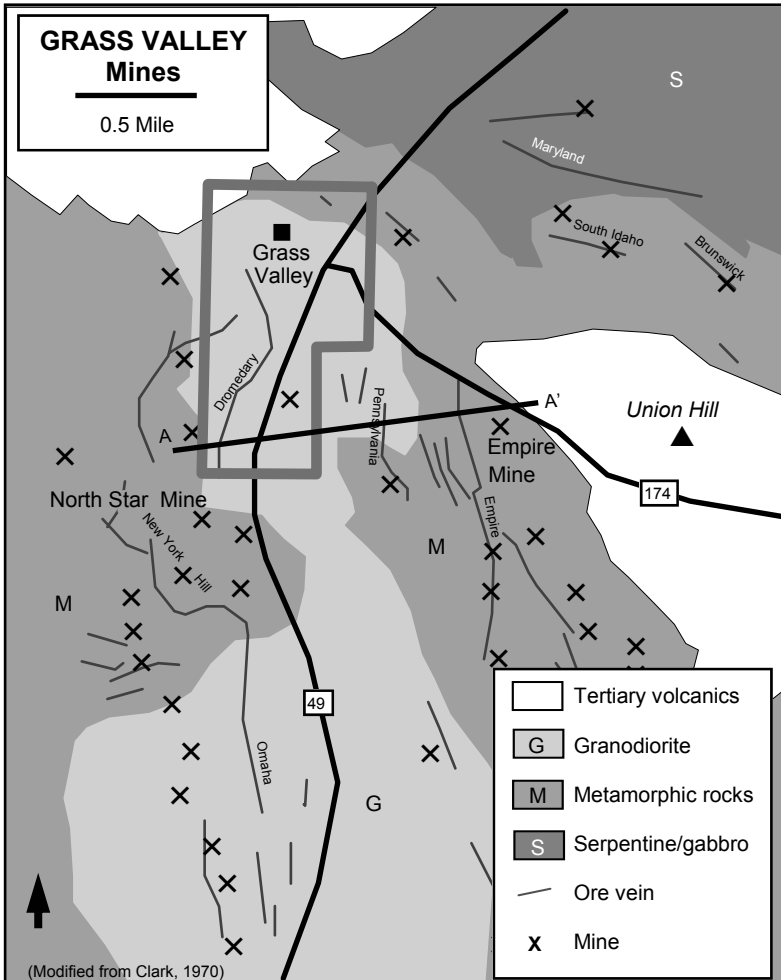
The Empire Mine State Historic Park is on the site of the Empire Mine, the largest of the mines in the Grass Valley area. The park has a museum with models and displays that give a good understanding of the mining operation. The park also has a self-guided tour of the restored mine buildings, workshops, offices, and mining equipment.

The Empire Mine operated from 1851 to 1956, except when it was forced to close during World War II. The combined Empire-North Star Mine had 367 miles of passages and was mined to a vertical depth of over one mile. The mine produced in excess of 5.8 million ounces of gold. At \$300/oz. that gold would be worth over 1.7 billion dollars.

The gold in the Empire Mine occurred in many different veins. Most of the veins were in granodiorite, and most dipped at about 35 degrees. The largest and most extensive of these veins was the Empire vein. Other important west-dipping veins included the Pennsylvania and Hanging Wall veins. The large North Star vein was also in granodiorite, but dipped gently to the north. The ore is mainly free gold, with varying amounts of iron, lead, copper, and zinc sulfides. Distribution of the gold in the veins was erratic, but some of the veins extended thousands of feet.



The yard of the Empire Mine is adjacent to the visitor center and museum. The remains of the slanting headframe of the mine are in the center of the photo. Other buildings include a machine shop, blacksmith shop, and compressor building. The mine office, refinery room, and the foundations of the stamp mill and cyanide plant are adjacent to the mine yard.



#### ④ **Malakoff Diggins**

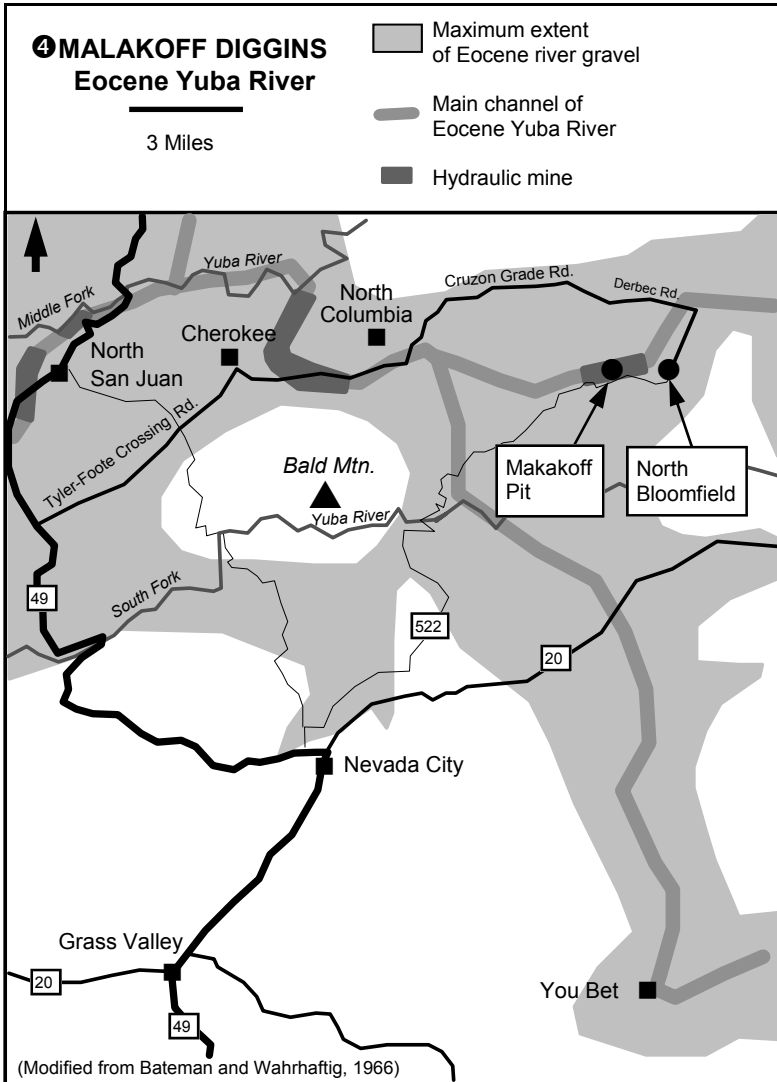
During the late 1870's and early 1880's the Malakoff Diggins was one of the largest hydraulic mining operations in the Sierra Nevada. The nearby town of North Bloomfield served as the center for the Malakoff Mine and several nearby hydraulic mines. Other large hydraulic mines in this area included Lake City to the west, Derbec to the north and Relief to the east.

**North Bloomfield** - From Nevada City take Hwy. 49 N 11 mi.; turn right on Tyler Foote Crossing Rd.; bear left on Cruzon Grade Rd. and follow the signs 17 miles to Malakoff Diggins State Historic Park.

In the early 1880's, at the height of the hydraulic mining activity, the town of North Bloomfield had 1,700 residents, including a large settlement of Chinese immigrants. There were eight saloons, two churches, five hotels, and the other business establishments common to gold rush towns. In 1884, hydraulic mining activities abruptly ceased, as a result of a famous court case known as the "Sawyer decision" that prohibited the dumping of hydraulic mining debris into the local rivers. The town was off the beaten track and had little other economy, so it slowly became a ghost town. After years of neglect, most of the buildings had fallen into ruin or disappeared. In 1966, North Bloomfield became a state park. Following this, the few buildings that were still standing were preserved, and other buildings were reconstructed from original plans.



This monitor near the West Point Overlook now lies silent on the floor of the Malakoff Pit. During the 1870's as many as a dozen monitors were used in the hydraulic mining of the pit.



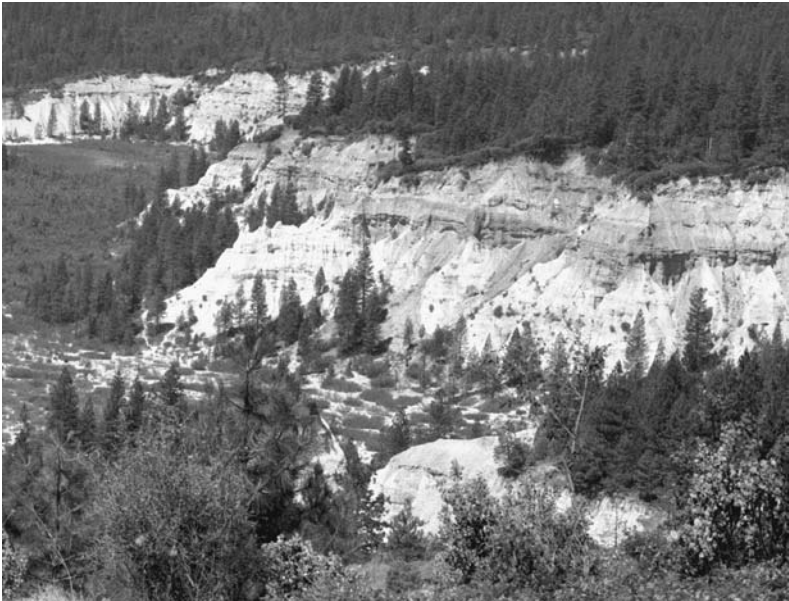
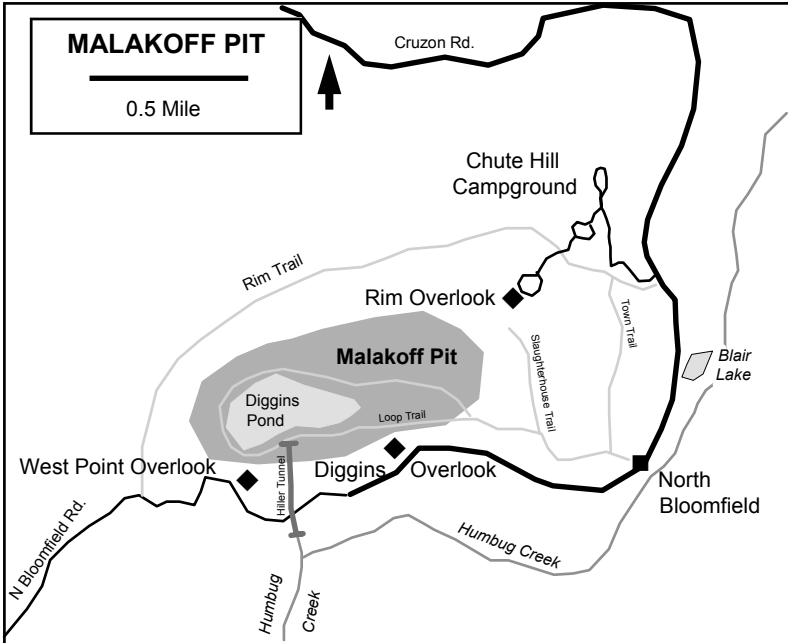
Malakoff Diggins State Historic Park has a museum in a former saloon on Main Street with displays and artifacts from the hydraulic mining era (530-265-2740 or [www.parks.ca.gov](http://www.parks.ca.gov)).

**Malakoff Pit** - *From North Bloomfield drive N 1 mi. to the Chute Hill Campground; follow the signs in the campground to the Rim Overlook.*

From the Rim Overlook at the Chute Hill Campground, you can see the large Malakoff Pit that was formed by the hydraulic mining of the Eocene river gravel. The pit is over one-and-one-half miles long and a half-mile wide. At the time of the hydraulic mining operations, the pit was 600 feet deep. It has partially filled in since then, and is now about 300 feet deep. The gold occurs in Eocene river gravels that were deposited in the Middle Fork of the Eocene Yuba River. The gravel is up to 600 feet thick in this area. Most of the gold was in the lower 130 feet of blue gravel.

Although the blue gravel at the Malakoff Mine was rich, two things had to be done to reach the gravel. First, several hundred feet of nearly worthless overlying gravel had to be removed. Then, in order to get to the high-grade ore at the bottom of the channel, it was necessary to drain the mining pit. In 1874, work was completed on the 8,000-foot Hiller Tunnel that was dug in hard bedrock and provided drainage from the pit into Humbug Creek. Following completion of the tunnel, operations expanded, and the mine operated seven monitors 24 hours a day, expelling huge amounts of tailings into the Yuba River.

The mining was carried out by the North Bloomfield Gravel Mining Company. An extensive system of ditches and flumes supplied water to the mining operation from Bowman Lake and other reservoirs in the High Sierra. The hydraulic operations continued to expand rapidly during this period. By 1875 tailings from the mine were creating a major environmental problem. The tailings polluted streams and rivers and killed fish. Silt reached into San Francisco Bay and passed into the Pacific through the Golden Gate. The Yuba and Sacramento Rivers were no longer navigable for ocean-going vessels. The bed of the Sacramento River rose and farmland and cities flooded. Finally, because of the ruination of much farmland, farmers filed a lawsuit to stop the hydraulic mining. In 1884, Judge Lorenzo Sawyer issued an injunction against dumping mine debris into the Sacramento and San Joaquin Rivers and their tributaries. The Sawyer decision effectively stopped hydraulic mining in northern California. It is estimated that the North Bloomfield Gravel Mining Company spent three million dollars on capital improvements to carry out their hydraulic mining operation. They recovered about three million dollars in gold before the mining operations were stopped by the Sawyer decision.



This view from the Rim Overlook at the Chute Hill Campground shows the Eocene river gravels that are exposed along the north wall of the Malakoff Pit.

## ⑤ **Yuba River**

North of Nevada City, Highway 49 travels for 20 miles on top of the Eocene erosion surface. The weathered rocks of the Western Metamorphic Belt and the red soil that was developed on this surface are exposed in many of the roadcuts along the highway. These red soils are especially well developed at Camptonville. Near North San Juan and Camptonville, isolated patches of Eocene gravels that have been preserved on the Eocene erosion surface have been hydraulically mined for their gold.

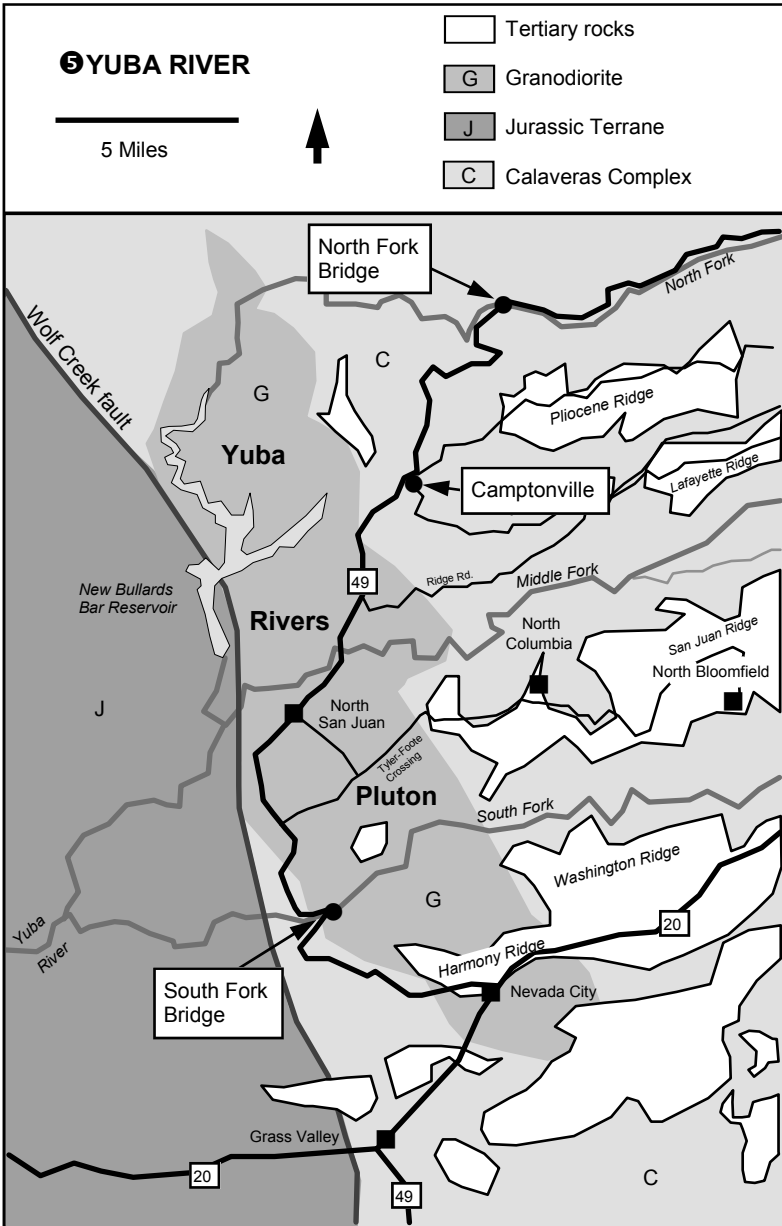
On the trip north from Nevada City on the Eocene erosion surface, Highway 49 crosses the South, Middle and North Forks of the Yuba River. During the Plio-Pleistocene uplift of the Sierra, these rivers cut deep valleys into the Eocene erosion surface. The rocks of the Western Metamorphic Belt are fresh and well exposed in the bottoms of these river valleys. The best places to see these rocks are in the vicinity of the Highway 49 bridges that cross the rivers.

Erosion of the soft Tertiary sedimentary and volcanic rocks that lie on top of the Eocene erosion surface is rapidly working its way eastward from the foothills toward the crest of the Sierra. From Nevada City to Camptonville, most of the Tertiary rocks west of Highway 49 have been removed from the erosion surface, whereas east of the highway a number of broad ridges are still covered by the Tertiary rocks. These include Harmony Ridge, Washington Ridge, San Juan Ridge, Lafayette Ridge, and Pliocene Ridge. The road from North San Juan to North Bloomfield follows the San Juan Ridge and provides a good look at the Tertiary sedimentary and volcanic rocks.

**South Fork Bridge** - *From Nevada City, drive N on Hwy. 49 7 mi. to the bridge across the South Fork of the Yuba River; park in the designated parking area; this is a popular swimming area; if the weather is warm bring your bathing suit.*

North of Nevada City, Highway 49 traverses the erosion surface for several miles and then abruptly descends into the deep canyon of the South Fork Yuba River. This canyon cuts into the Sierra basement rocks below the Eocene erosion surface. The rocks exposed along the bottom of the canyon at the highway bridge are granodiorite of Jurassic age. These rocks are part of the large Yuba Rivers Pluton, an outlier pluton of the Sierra Nevada batholith that has been intruded into the rocks of the Western Metamorphic Belt. The pluton is about 20 miles long and four miles wide, and extends across the three major forks of the Yuba River.





**Camptonville** - *From the South Fork bridge, drive 14 mi. N on Hwy. 49 to Camptonville; turn right and follow the signs into the town.*

Camptonville lies on the thick red soil of the Eocene erosion surface. In roadcuts near town there are good exposures of the red soil and the deeply weathered basement rocks below the red soil. The basement rocks are metavolcanics of the Western Metamorphic Belt and are so thoroughly decomposed that they can easily be crushed by hand.

The rich blue lead of the north branch of Eocene Yuba River goes through the Camptonville area. Most of the Tertiary sedimentary and volcanic rocks have been eroded from this area, so the gold-bearing river gravels in this area are covered only by a thin layer of dirt and rock. The river gravels were, thus, ideally suited to hydraulic mining, and the town prospered with this activity in the late 1850's. Unfortunately, the original town was situated on one of the Eocene river channels and the hydraulic operations ate away the land that the town had been built on, forcing the town to move to higher ground.

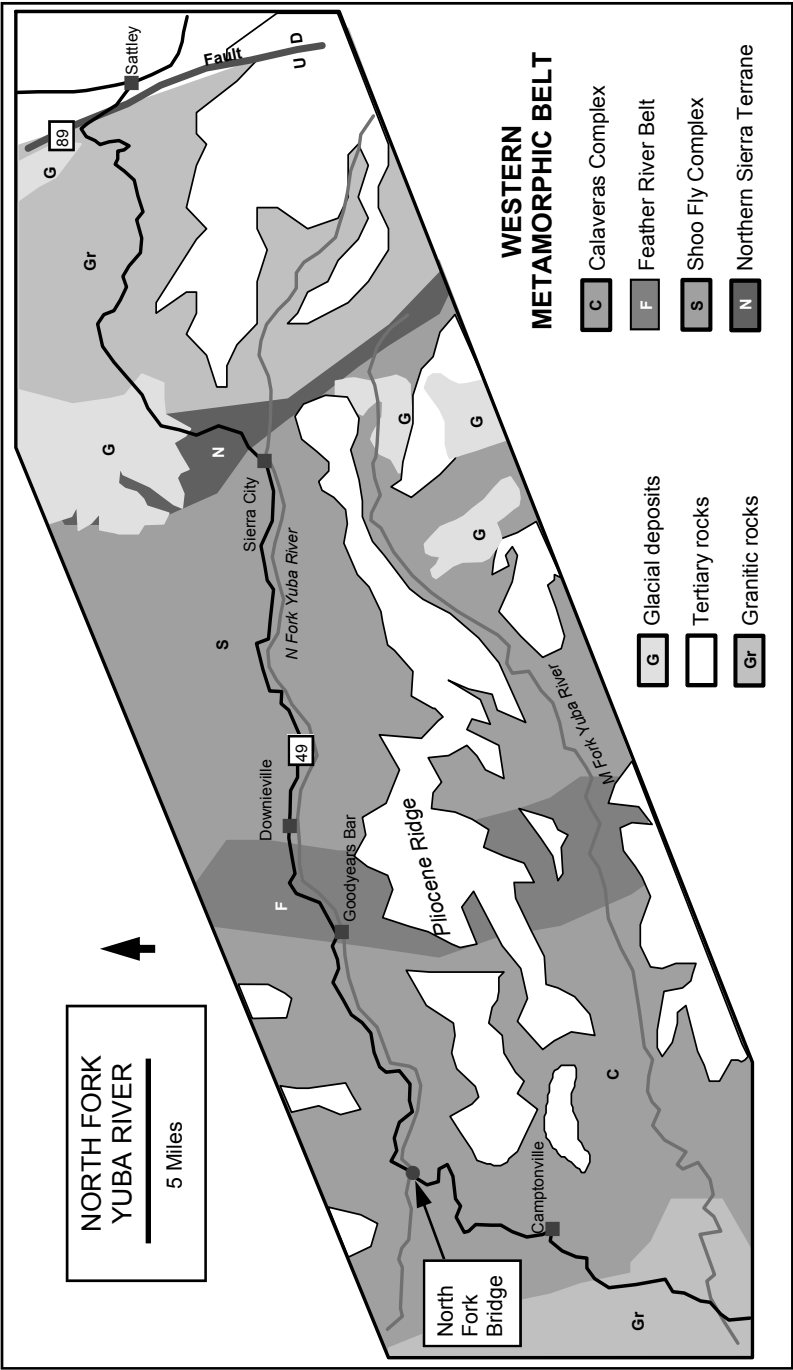
The Pelton water wheel was invented at Camptonville by Lester Pelton in 1878. These water wheels powered many different types of mining machinery in the northern Sierra, and were used for many years in the Empire and North Star Mines of the Grass Valley area.

**North Fork Bridge** - *From Camptonville drive N 9 mi. on Hwy. 49 to the bridge that crosses the North Fork of the Yuba River; park at the bridge.*

North of Camptonville, Highway 49 crosses the North Fork of the Yuba River and then follows the river up the western flank of the Sierra Nevada. Over much of this distance, the river has been incised into the rocks of the Western Metamorphic Belt, and the metamorphic rocks are well exposed along the river and in many roadcuts.

The metamorphic rocks from the North Fork bridge to Goodyears Bar belong to the Calaveras Complex. The rocks near the bridge are partially metamorphosed volcanic rocks, and consist of basalt, agglomerates, and tuffs. Some of the tuffs have been recrystallized into schist, and others are only partly altered.

The Downieville Museum at 330 Main St., Downieville, is located in a former Chinese store and gambling house. The museum has a good display of local gold rush relics.



## ⑥ Goodyears Bar

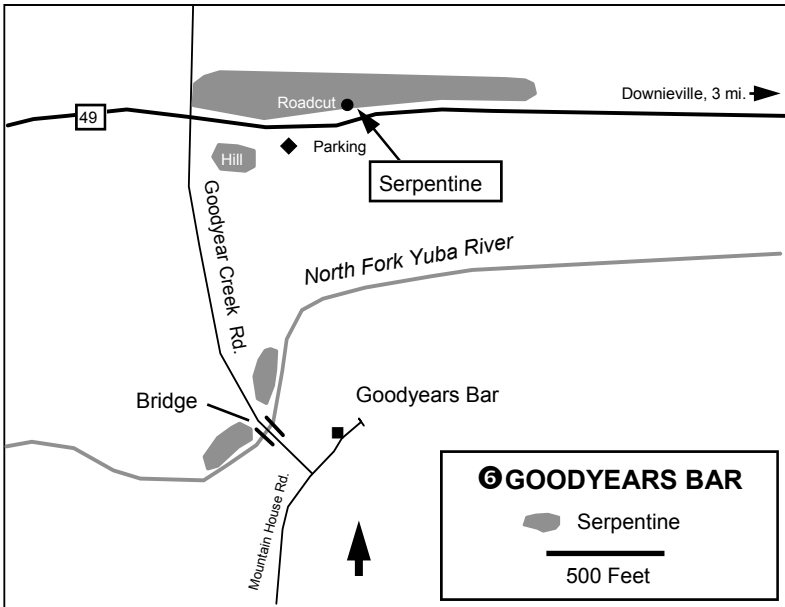
Rich placer gold deposits were discovered at Goodyears Bar in 1849, and the area prospered during the 1850's, until the placer deposits were exhausted. At Goodyears Bar, Highway 49 crosses through a sequence of ultramafic rocks known as the Feather River Belt. These rocks lie between the Calaveras Complex and the Shoo Fly Complex, and represent a slab of oceanic crust that was carried into the Calaveras subduction zone and inserted under the rocks of the Shoo Fly Complex.

The Feather River Belt includes serpentine, metamorphosed sedimentary and volcanic rocks, gabbro, amphibolite gneiss, and blueschist. In the northern Sierra, the belt ranges up to several miles wide. To the south, the belt narrows and becomes the Calaveras-Shoo Fly fault. The rocks of the Feather River Belt near Goodyears Bar are mainly serpentine.

**Serpentine** – From Downieville drive 3 mi. W on Hwy. 49 to Goodyear Creek Rd.; the serpentine roadcut is on the N side of the highway immediately E of Goodyear Creek Rd.

The serpentine of the Feather River Belt can be found in many places near Goodyears Bar. However, the best exposures are in the large roadcuts along Highway 49 just east of the turnoff to Goodyears Bar. There are also good exposures of the serpentine along the South Fork of the Yuba River near the bridge where Goodyear Creek Road crosses the North Fork. Some of this serpentine displays a very intense green hue, and is specimen quality.





↑ This large roadcut on Highway 49 near Goodyear Creek Road has excellent exposures of serpentine from the Feather River Belt.

← The serpentine is also exposed along North Fork of the Yuba River at the bridge for Goodyear Creek Road.

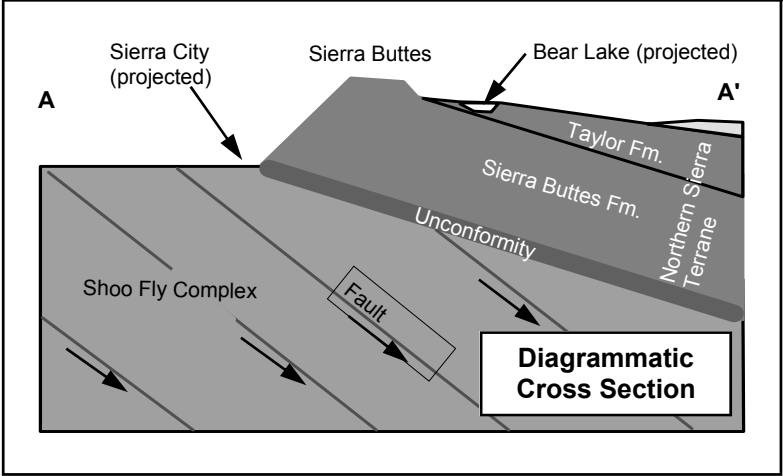
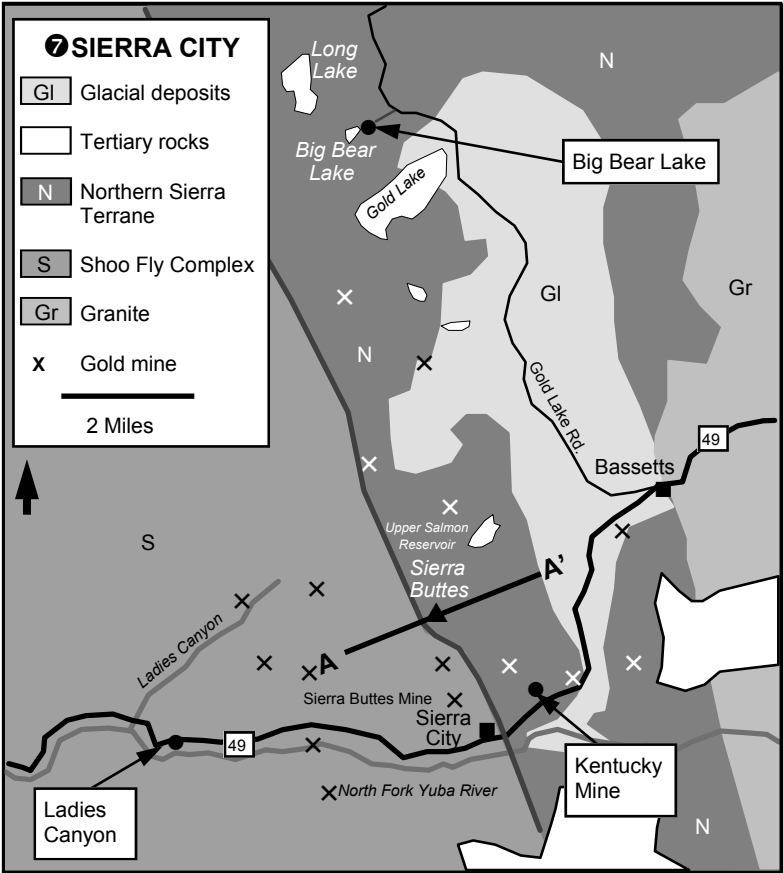
## 7 *Sierra City*

Sierra City was founded in 1850, following discovery of placer gold in the North Fork of the Yuba River. A short time later, lode deposits were discovered in the mountains north of town. The large Sierra Buttes Mine was opened in 1850 and was followed by many other discoveries, including the nearby Kentucky Mine. The district was highly productive from 1870 to 1914, but was only intermittently productive thereafter. There is little mining at present.

The placer deposits at Sierra City contained many large gold nuggets, and the mines were known for their very rich high-grade surface pockets of gold. The gold occurs as free gold in a series of north-trending quartz veins that range up to 40 feet in thickness. Some of the veins are several hundred feet long and several thousand feet deep. Most of the quartz veins are in slate and metamorphosed rhyolite, but veins also occur in many other igneous and metamorphic rocks in this area.

This part of the Western Metamorphic Belt includes two very different types of metamorphic rocks, the Shoo Fly Complex and the Northern Sierra Terrane. The rocks of the Shoo Fly Complex are of Cambrian to early Devonian age and consist mainly of metamorphosed slate, schist and chert. These rocks are well exposed in the roadcuts along Highway 49 near Ladies Canyon west of Sierra City. During mid-Devonian time, the rocks of the Shoo Fly Complex were subjected to a major period of mountain building, referred to as the Antler orogeny. During this orogeny, the rocks of the Shoo Fly Complex were folded, faulted, metamorphosed, uplifted, and eroded. As a result of the Antler orogeny, the Shoo Fly Complex was added to the western margin of North America.

The Northern Sierra Terrane consists of great thicknesses of volcanic rocks of late Devonian to Permian age. These rocks were deposited on top of the Shoo Fly Complex, and are separated from the Shoo Fly Complex by a major unconformity. This unconformity represents the mid-Devonian interval of geologic time during which the Antler orogeny was in progress. The rocks below the unconformity were affected by the Antler orogeny, and the rocks above the unconformity were not affected. The Sierra Buttes, north of Sierra City, are formed from rocks of the Northern Sierra Terrane, and these rocks extend north from the Sierra Buttes for about 30 miles, passing through the Gold Lake and Big Bear Lake areas. Some of the best exposures of these volcanic rocks are at Big Bear Lake where the rocks have been cleaned off and polished by glaciers.



**Ladies Canyon** – From Sierra City drive 5 mi. S on Hwy. 49; park in the pullout near milepost 24.27, 300 feet N of the Ladies Canyon Bridge.

The metamorphosed sedimentary rocks of the Shoo Fly Complex are exposed in many places between Downieville and Sierra City. One of the best places to examine these rocks is in the roadcuts near Ladies Canyon. The rocks in this area are mainly slate, phyllite, and schist, and occur in thin, steeply dipping layers. The rocks of the Shoo Fly Complex are of Cambrian to early Devonian age and were derived from the North American continent when the continent lay far to the east of the present-day Sierra. The rocks were folded, faulted and metamorphosed during the mid-Devonian Antler orogeny.

**Kentucky Mine** - From Sierra City drive 1 mi. E on Hwy. 49 to the Sierra City Historical Park and Museum (530-862-1310).

The Sierra City Historical Park and Museum is on the grounds of the Kentucky Mine, one of early lode mines in the Sierra Buttes area. The six-story Kentucky Mine operated from the 1850s to 1953. The portal to the mine's 1500-foot horizontal mineshaft is on the side of the mountain just above the museum. The park also has an operational 10-stamp mill, blacksmith shop, and miner's cabin. There are guided daily tours of the mill, with stops to explain the milling and extraction process.



The craggy Sierra Buttes, which lie north of Sierra City, are formed from volcanic rocks of the Northern Sierra Terrane. These rocks were deposited along an island arc during late Devonian time along what was then the western border of the North American continent.





The metasedimentary rocks of the Shoo Fly Complex in this roadcut near Ladies Canyon dip steeply and are mainly thinly layered phyllite and schist. These are some of the oldest rocks of the Western Metamorphic Belt.



Gold ore from the Kentucky Mine was carried in small ore cars across this trestle to the mill where the gold was processed. The mill is open for tours and is typical of the mills of the Sierra Nevada gold belt.

**Big Bear Lake** - From Sierra City go 5 mi. N on Hwy. 49; at Bassetts turn left on Gold Lake Rd. and drive 9 mi. to the turnoff to Lakes Basin Campground; take the Big Bear Lake trail from the campground and hike 0.5 mi. to the S shore of the lake.

The volcanic rocks of the Northern Sierra Terrane are about three miles thick and were deposited by a series of island arcs that existed along the western margin of North America during late Devonian to Permian time. Deposition of these rocks began immediately after the end of the Antler orogeny. Most of these rocks were deposited under water. After the volcanic material was ejected from the volcanoes along the arcs, it accumulated on the slopes of the volcanoes and then slumped and flowed into the ocean basins between the arcs. The rocks of the Northern Sierra Terrane have been divided into several different formations, depending on the age of the deposits and compositional differences of the units. From oldest to youngest, these include the Sierra Buttes, Elwell, Taylor, Peale, Goodhue and Reeve formations.

The Sierra Buttes Formation is the oldest, lowermost, and one of the best-known rock units in the Northern Sierra Terrane. These rocks lie directly on the Shoo Fly Complex, and represent the earliest volcanic activity that took place after the Antler orogeny. The Sierra Buttes, which lie immediately north of Sierra City and rise 3,000 feet above the city, are formed from these rocks. The Sierra Buttes Formation is also well-exposed at Jamison Lake, about ten miles north of Sierra City.

One of the best places to see the volcanic rocks of the Northern Sierra Terrane, however, is at Big Bear Lake, about 15 miles north of Sierra City. The volcanic rocks of the Taylor Formation have been cleaned and polished by glaciers and are well exposed along the shoreline of this scenic lake. As described by Brooks (2000), these rocks are mainly basaltic in composition, and consist of pillow lavas, turbidites, and debris flows. The pillow lavas appear as rounded blobs a foot or so across, and some have margins that are brick red. The turbidites are fine to very coarse-grained and stratified. Some strata show graded bedding.

Along the road to the Lakes Basin Campground, there are several small rounded outcrops of the Taylor Formation that were cleaned and polished by Pleistocene glaciers and have been used as a drawing board by early inhabitants of this area. The petroglyphs on these rocks include pictures of humans, animals, mystical beings and geometric designs. The drawings were made by pounding or pecking the pictures in the rocks.



The volcanic rocks of the Northern Sierra Terrane are well-exposed along the shore of Big Bear Lake where Pleistocene glaciers cleaned and polished the rocks. The rocks at the lake include pillow basalts, turbidities, and debris flows that were deposited along island arcs in late Devonian time.



This small *roche moutonnée* near the Lakes Basin Campground is inscribed with a number of petroglyphs made by early inhabitants of the area. This rock is part of the Taylor Formation, and is similar to the volcanoclastic rocks at Big Bear Lake.