Guide for the Earth Science Week Field Trip, October 16 or 17, 2010
Nevada Bureau of Mines and Geology Educational Series E-50

In Search of Tufa, Tuff, and Tough Rocks

National Earth Science Week 2010 encourages people everywhere to explore the natural world and learn about the geosciences. Nevada Bureau of Mines & Geology welcomes you to participate in its thirteenth annual Earth Science Week field trip. We will travel from Reno east on Interstate 80 to Fernley and north to Winnemucca Lake where we will explore several tufa formations left exposed around the lake's perimeter following diversion of part of the Truckee River's water for use in the Newlands Irrigation Project. From here we will continue traveling east to the Nightingale Mountains where we will visit the historic Nightingale Mining District where tungsten and other minerals were mined in the early 1900s. We will return to Reno via one of two alternate routes, one of which will take us by the historic Bradys Hot Springs on Interstate 80, now used to power a geothermal energy plant, or the other route via Sutcliffe on Pyramid Lake and the Pyramid Highway. Along the way, we will visit several sites where we can examine and collect a wide variety of interesting rocks that help earth scientists unravel the geologic history of the area surrounding Reno and Pyramid Lake.

STARTING POINTS: Field trip participants wanting a tour of the **Great Basin Science Sample and Records Library (GBSSRL)**, the new building for information, publication sales, topographic maps, and geological samples of the Nevada Bureau of Mines and Geology, can meet there, **2175 Raggio Parkway, Reno, NV 89512** (on the west side of the Desert Research Institute campus) at 8:00 a.m.
We'll leave GBSSRL promptly at 8:30 a.m. and rendezvous with other participants who would prefer to join us at our alternate starting point, the **I-80 Smokeshop and gas station run by the Pyramid Lake Paiute Tribe north of Fernley on NV 427 (Main Street) at Wadsworth, near the Interstate 80 exit to Pyramid Lake.** After a short break, we'll leave the I-80 Smokeshop Reservation at 9:15 a.m.

The general overall route of the field trip is shown on the accompanying satellite view map with the geology stops indicated as numbered dots. Entire round trip mileage from Reno and back will be about 150 miles. Mileages given are cumulative. Vehicle odometers may differ, so keep track of landmarks and stay behind lead vehicles. It will be helpful to have someone in your vehicle read the geological descriptions of sites along the route as we travel.

Figure 1. Overall route and stops of the field trip, Google Earth image from the U.S. Geological Survey.

Mile 0.0. Road log begins at the I-80 Smokeshop [N 39°37.166', W 119°18.350']. Latitudes and longitudes are given using the WGS'84 datum, which is the default datum for most hand-held global positioning system (GPS) units. Set your odometer trip mileage to 0.0. Travel northeast toward the center of Wadsworth, then north toward Pyramid Lake.

Mile 1.1 [N 39°37.845', W 119°17.434']. Turn left (north) onto Route 447 toward Pyramid Lake.

The Olinghouse mining district and Olinghouse mine are in the Pah Rah Range to the northwest of Wadsworth. Discovered in 1860, the area has experienced intermittent gold and silver (and minor copper, lead, and tungsten) mining into the present day. The ores occur in volcanic rocks.

Shorelines of ancient Lake Lahontan will be visible in the low parts of the hills throughout the day. Geologists have measured elevations of and dated the various high stands of Lake Lahontan, including one at approximately 4,370 to 4,386 feet above sea level about 13,000 years ago. (For maps and references on the geology along the Truckee River between Wadsworth and Pyramid Lake, see Bell and others, 2005, Geologic map of the Nixon area, Washoe County, Nevada: Nevada Bureau of Mines and Geology Map 152, 1:24,000 scale; and Geologic map of the Wadsworth quadrangle, Washoe County, Nevada: Nevada Bureau of Mines and Geology Map 153, 1:24,000 scale). Deformation of the Earth due to loading of water in the lake (depressing the land when the lake is at a high stand, rebounding when the lake dries out) makes the high shoreline slightly uneven.

The route takes us past exposures of Lake Lahontan sediments in the canyon of the Truckee River. These include deposits that are correlated with the last major glacial event about 11,000 to 40,000 years ago and multiple glacial events that occurred between about 130,000 to 350,000 years ago. There are also locally older lake sediments that are not correlated with glacial events.

Mile 16.3 [N 39°49.233', W 119°21.755']. At the Nixon Store and the intersection with Route 446 (which goes to the west side of Pyramid Lake), stay straight on Route 447, which continues to the north.

In 1906, as the Newlands Project began diverting Truckee River water to the Carson River for irrigation in the Fallon area, the lake stood at approximately 3,871 feet above sea level. In 1989, it stood at approximately 3,788 feet above sea level. The deepest part of the lake is approximately 3,512 feet above sea level.

A quick review of the geology of the Reno-Pyramid Lake region may help understand what we will see during the day. The oldest rocks of the region are **Triassic** (251 to 200 million years old) to **Jurassic** (200 to 145.5 million years old) sedimentary rocks (mostly marine limestones, shales, and siltstones) and volcanic rocks (mostly andesites and rhyolites) that are locally metamorphosed near Jurassic and **Cretaceous** (145.5 to 65.5 million years old) intrusions (crystallized bodies of magma). The Triassic and perhaps some of the Jurassic rocks probably didn't form in place but were attached to the North American continent during past continental collisions. We'll drive past Triassic-Jurassic metamorphosed limestone and dolomite at Marble Bluff, the first hill north of Nixon, on our way to the first stop. The Jurassic and Cretaceous intrusions were probably the roots of volcanoes like the Andes or Cascades today, formed by subduction of oceanic crust beneath North America. Much of the Sierra Nevada is underlain by Cretaceous granodiorite.

Granodiorite is an intrusive igneous rock (solidified from a magma that intruded below the surface, not erupted at the surface from a volcano) composed mainly of the following minerals in decreasing abundance:

- plagioclase feldspar (a solid solution dominantly between the end members albite, $NaAlSi_3O_8$, and anorthite, $CaAl_2Si_2O_8$),
- potassium feldspar (orthoclase or microcline, $KAlSi_3O_8$), quartz (SiO_2),
- hornblende ($Ca_2(Mg,Fe)_4Al(Si_7Al)O_{22}(OH,F)_2$),
- biotite ($K(Mg,Fe)_3AlSi3O_{10}(OH,F)_2$)

  and lesser variable amounts of these minerals:
- magnetite (Fe_3O_4)-ulvospinel (Fe_2TiO_4) solid solution
- ilmenite ($FeTiO_3$)-hematite (Fe_2O_3) solid solution
- apatite ($Ca_5(PO_4)_3(OH,F)$)
- zircon ($ZrSiO_4$)
- titanite ($CaTiSiO_5$)
- monazite ($CePO_4$)
- xenotime (YPO_4)

Intrusive igneous rocks have chemically equivalent extrusive (volcanic) rocks. With increasing silica concentrations (from lowest in gabbro to highest in granite), the common igneous rocks are:

Intrusive		Extrusive
Gabbro	=	Basalt
Diorite	=	Andesite
Granodiorite	=	Dacite
Granite	=	Rhyolite

We will look for examples of several of these igneous rock types on our field trip today.

Erosion during the late Cretaceous and early **Tertiary** (65.5 to 2.6 million years ago) stripped away Cretaceous volcanic rocks. **Eocene** (55.8 to 33.9 million year old) and **Oligocene** (33.9 to 23.0 million years old) calderas (large, explosive "supervolcanoes") erupted in central Nevada and sent ignimbrites or welded and non-welded **tuffs** (composed of ash, crystals, pumice, and rock fragments) down river channels toward the Pacific Ocean. The volcanic arc of the Cascades was in the Reno area during the **Miocene** Epoch (23.0 to 5.3 million years ago), but its southernmost volcano (now at Mount Lassen) has changed as the San Andreas fault and the Mendocino fracture zone in the Pacific Plate have moved northward with time. In the Reno area, Oligocene tuffs locally fill river channels that were cut into Cretaceous and older rocks, and Miocene volcanic rocks (including basalt, andesite, dacite, and rhyolite) overlie Oligocene tuffs and older rocks.

Hydrothermal (hot water) activity associated with Jurassic intrusions near Yerington produced large copper deposits. Similarly, hydrothermal fluids associated with Cretaceous intrusions produced numerous tungsten deposits, including those in the Nightingale Mountains, and hydrothermal fluids associated with Miocene volcanoes produced the Comstock Lode at Virginia City and many other silver and gold deposits in the region. Diatomite (mined today for industrial uses as an absorbent and filter) and limestone (mined near Fernley as one of the ingredients in cement) were locally deposited in Miocene lakes in the region.

Most rocks exposed in the Truckee River canyon between Reno and Wadsworth are Miocene volcanic and sedimentary rocks. We'll also see patches of fine-grained, horizontally layered sediments that were deposited in Lake Lahontan, a **Pleistocene** (2.6 million to 11,700 years ago) lake that covered much of the lowlands in western Nevada during glacial times. Pyramid Lake, Walker Lake, and ponds in the Carson and Humboldt sinks are remnants of ancient Lake Lahontan. Tufa deposits (see below) are also visible low on the walls of the Truckee River canyon, and **Quaternary** (2.6 million years ago to present) basalt crops out near Lockwood. Miocene basalt and rhyolite are mined east of Reno for use in construction as the aggregate for concrete and asphalt.

Geologic processes are still quite active in this area. Two primary types of Quaternary faults occur throughout the region: (1) Normal faults are related to crustal extension that gives us the basin and range topography of Nevada, and (2) Strike-slip faults here are northwest-striking, right-lateral strike-slip faults in the region that account for approximately 20 to 25% of the motion between the Pacific and North American plates, most of which is taken up along the San Andreas and parallel faults in California. Hydrothermal (geothermal) activity is associated with many Quaternary faults in the region, and may be related to Quaternary volcanism near Steamboat Hot Springs at the south end of Reno. Hydrothermal alteration of the volcanic rocks in the Reno area causes some problems with construction as a result of converting the glass and original minerals in the Miocene volcanic rocks to clays that expand when they get wet and contract when they dry out. Many hydrothermal fluids also contained substantial quantities of arsenic, which results in local concentrations of arsenic in well water.

Mile 25.2 [N 39°56.602', W 119°23.003']. Exiting the Pyramid Lake Paiute Reservation. We'll return to this spot soon. Continue 1.9 miles farther north on Route 447 to the turnoff.

On the southwest side of Winnemucca Lake we will see many exposures of **tufa**, a type of limestone that forms in lakes and streams. Tufa (or limestone) is composed primarily of the mineral calcite ($CaCO_3$). It forms where ground water from springs interacts with lake water. (See Benson, 2005, The tufas of Pyramid Lake, Nevada: U.S. Geological Circular 1267, 24 p. for a discussion of tufa in this area.) The spring water was probably undersaturated with respect to calcite but may have carried dissolved calcium that reacted with dissolved carbonate in the alkaline lake water, thereby precipitating calcite. Calcite is an unusual solid in that it dissolves more readily at lower temperature than higher temperature, such that calcite will precipitate, rather than dissolve, when water that is saturated is heated. Thus hot groundwater interacting with cool, saturated lake water could cause precipitation. If the water loses dissolved CO_2 through degassing to the atmosphere, which can occur as deep groundwater loses pressure coming up from below in a spring, the water will become less acidic (pH will rise), which also promotes calcite precipitation. Whether microbial activity is also necessary for tufa to form is not fully understood. We'll see tufa mounds of various dimensions today, ranging from a few centimeters in diameter to tens of meters in overall dimensions. Tufa may also form along the shores of the lake; calcite is one of the first minerals to precipitate from evaporating water as the lake level dropped during dry periods.

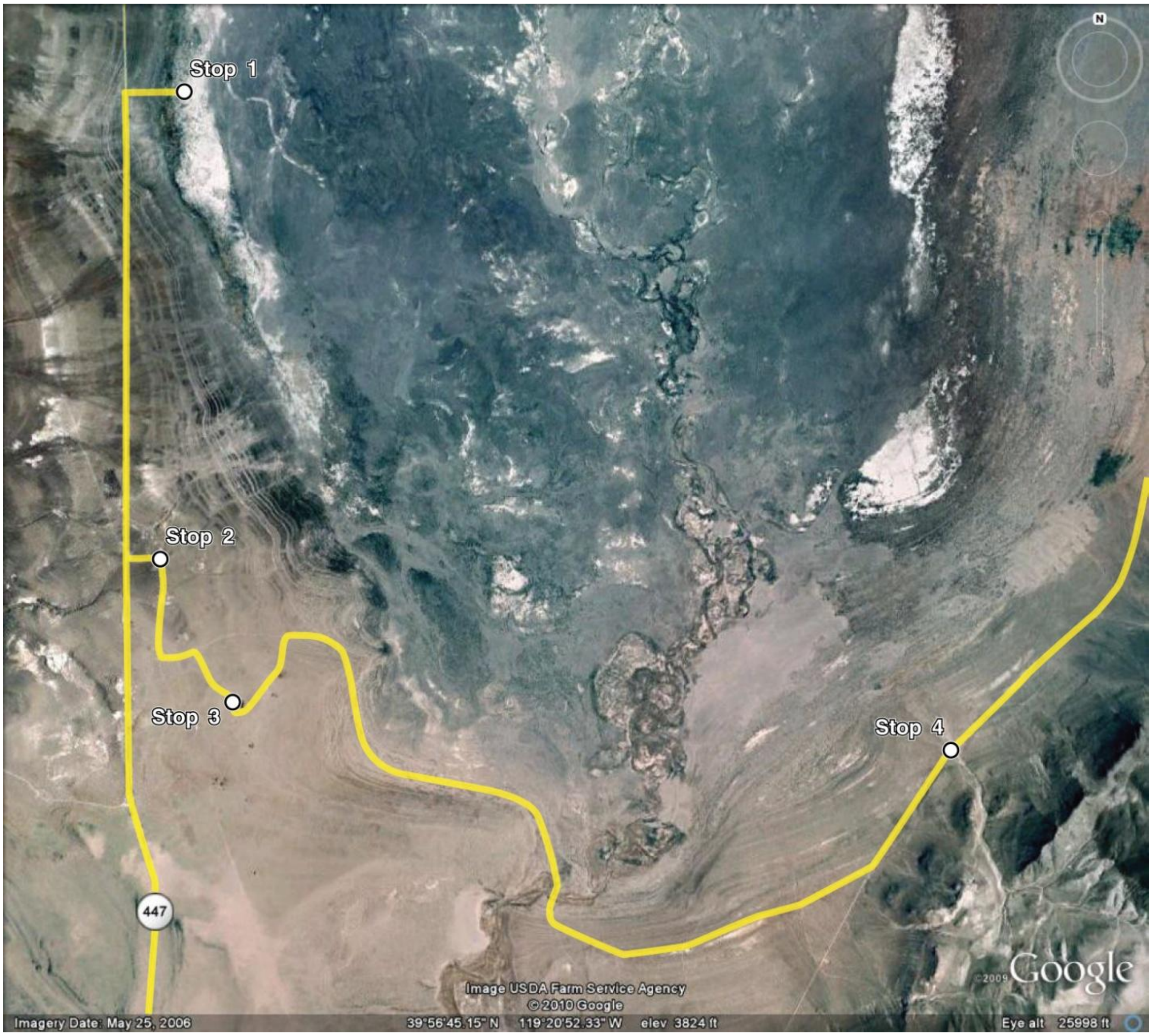

Figure 2. Route to Stops 1, 2, 3, and 4.

Mile 27.1 [N 39°58.278', W 119°23.015']. Turn right, onto a dirt road east toward the playa of Winnemucca Lake.

Mile 27.3 [N 39°58.317', W 119°22.694']. **STOP 1.** Collect tufa pipes and heads eroded from nearby small tufa mounds and basalt from Miocene lava flows in Lake Range to the west. Also examine mud cracks that formed when the lake-sediment clay dried out.

The pipes are tubes of tufa, and the heads are the top ends of the tubes, where spring water and lake water reacted to precipitate calcite.

Interestingly, the tufa here and at other localities in Nevada fluoresces in short-wave ultraviolet light. On surfaces that have been exposed to weathering and the sun, the fluorescent color is orange. The surfaces that were exposed to the sun when the samples were collected fluoresce a brighter orange than the bottom sides of the samples. Samples that were probably eroded from their original outcrops and rolled over repeatedly by stream or wave action fluoresce orange on all sides. Fresh surfaces (exposed when the rock is chipped with a hammer or cut with a diamond saw) fluoresce weakly as pale yellow.

Figure 3. Photograph of tufa pipes and heads from Stop 1. The scale is in centimeters; 2.54 cm = 1 inch.

Figure 4. Photograph of mud cracks on Winnemucca Lake.

Figure 5. Photograph of Oligocene tuffs (reddish brown and beige rocks to the right) filling a river channel cut into Triassic-Jurassic sedimentary rocks (gray rocks to the left) in the south end of the Nightingale Mountains, looking east from Stop 1, across Winnemucca Lake.

Reset mileage to 0.0 at Stop 1. Retrace the route 2.1 miles back south on Highway 477, to the wide dirt road north of the entrance to the Pyramid Lake Paiute Reservation, at Mile 25.2.

Mile 2.1, same as Mile 26.2 [N 39°56.602’, W 119°23.003’]. Turn east (left) off Highway 477.

Mile 2.3 [N 39°56.612’, W 119°22.845’]. Turn left (north) and proceed 0.2 mile on the dirt road. You are welcome to walk this short distance.

Mile 2.5 [N 39°56.727’, W 119°22.803’]. **Stop 2.** Examine exposures of large, circular tufa mounds to the west. There are spectacular exposures of tufa mounds in this area. Some had mushroom shapes and toppled from their pedestals. Many in this area have circular or hemispherical geometries.

Figure 6. Photographs of tufa mounds, some of which have circular cross sections, at Stop 2.

Figure 7. Photograph of one large tufa mound. The hat, for scale, is 35 cm long.

Figure 8. Close-up photograph of tufa mound at Stop 2. Note the radiating crystals of calcite.

Figure 9. Photograph of the back side of the tufa mound in Figures 8 and 9.

Figure 10. Toppled, mushroom-shaped tufa mounds at Stop 2.


Figure 11. Toppled, mushroom-shaped tufa mound at Stop 2.

Return 0.2 mile to Mile 2.3 and reset your odometer there to 0.0.

Mile 0.0 [N 39°56.612', W 119°22.845']. Continue south on the dirt road.

Mile 0.4 [N 39°56.252', W 119°22.846']. Turn left (east).

Mile 0.5 [N 39°56.263', W 119°22.705']. Turn right (southeast) toward large tufa tower.


Figure 12. Tufa tower at Stop 3.

Mile 0.8 [N 39°56.034’, W 119°22.492’]. Stop 3. Examine large tufa towers and mounds in this area, then continue on the circular road around this tower.

Figure 13. Tufa tower at Stop 3.

Mile 0.9 [N 39°56.060’, W 119°22.436’]. Continue northeast and drive by other tufa mounds in this area.

Figure 14. Photograph, looking east from Stop 3, at dipping Triassic-Jurassic limestone beds (center) and horizontal Lake Lahontan shorelines lower on the hill at Stop 4.

Mile 1.1 [N 39°56.190', W 119°22.299']. Pass a tufa mound with more circular cross sections, like "Popcorn Rock" on the west side of Pyramid Lake. Continue northeast.

Mile 1.3 [N 39°56.318', W 119°22.255']. Turn right (east).

Mile 1.4 [N 39°56.316', W 119°22.087']. Turn right (southeast) where a road merges from the left.

Mile 1.5 [N 39°56.279', W 119°22.007']. Turn right (south) 30 degrees. Don't take the road to the left.

Mile 2.6 [N 39°55.761', W 119°21.233']. Continue to the southeast as another road comes in from the left.

Mile 3.2 [N 39°55.385', W 119°20.991']. Cross Mud Lake Slough, a former arm of the Truckee River, which fed Winnemucca Lake before the Newlands Project. The fine-grained Lake Lahontan sediments that crop out along the walls of the stream channel here were deposited during the late Wisconsinian glacial time, between 11,000 and 40,000 years ago (see Bell and others, 2005, Geologic map of the Nixon area, Washoe County, Nevada: Nevada Bureau of Mines and Geology Map 152, 1:24,000 scale).

Mile 3.3 [N 39°55.270', W 119°20.982']. Turn left (east) 30 degrees.

Mile 3.9 [N 39°55.193', W 119°20.334']. Keep left where a road merges from the right.

Mile 4.8 [N 39°55.479', W 119°19.471']. Keep left, heading northeast, where another road merges from the right.

Mile 5.3 [N 39°55.877', W 119°19.118']. **Turnoff for Stop 4.** Triassic-Jurassic limestone (high in the hills to the southeast) was intruded by Cretaceous granodiorite (along the bank of the streambed), which was overlain by conglomerate that is cemented by tufa.

Figure 15. Photograph of tufa-cemented gravel (conglomerate) overlying granodiorite at Stop 4.

Figure 16. Close-up photograph of tufa-cemented gravel (conglomerate) with imbricate pebbles that indicate the direction of the stream (from right to left) when the gravel was deposited.

Continue to the northeast on the main dirt road.

Mile 6.2 [N 39°56.384', W 119°18.415']. Continue straight. The road to the right goes to the White Caps/Crosby mine area, where tungsten was mined in the early 1900s.

Mile 6.8 [N 39°56.888', W 119°18.144']. Turn right (northeast) into Coyote Canyon.

Figure 17. Photograph of Oligocene tuffs (reddish brown and beige rocks in the center and to the right) and Triassic-Jurassic sedimentary rocks (dark gray rocks to the left) at the south end of the Nightingale Mountains, at Mile 6.8, looking north-northeast.

Figure 18. Aerial photographic view of Coyote Canyon and the middle of the Nightingale district.

Mile 9.0 [N 39°57.750', W 119°16.006']. Turn left (north) onto side road toward Stop 5.

Mile 9.3 [N 39°57.983', W 119°15.970']. **Stop 5.** Park your vehicle above the streambed and walk down the road to examine the outcrops of basalt and Oligocene tuff and samples of tuff and Cretaceous hornblende-rich diorite in the streambed. There are several layers of tuff in this area. In addition to the pink (when exposed on a fresh cut with a hammer, below the weathered, red surface) tuff that crops out near where the road drops into the streambed, boulders of white and green tuffs occur in the alluvium of the streambed. There are also boulders of Cretaceous granite, granodiorite, and diorite in the streambed.

Figure 19. Outcrop of tuff at Stop 5.

Return to vehicles and retrace route to main road in Coyote Canyon.

Mile 9.6 Back on the main dirt road in Coyote Canyon [N 39°57.750’, W 119°16.006’], same as Mile 9.0, **turn left** and continue to the northeast.

Mile 12.5 [N 39°59.119’, W 119°13.566’]. Don’t stop as you pass an outcrop of dipping, thin-bedded silty limestone and shale (Triassic-Jurassic) on the southeast side of the road (private property area) . Continue northeast.

Mile 13.6 [N 39°59.886’, W 119°13.245’]. **Stop 6,** at the crest of the hill. Examine and collect Cretaceous granodiorite, then continue northeast on the same road.

Mile 14.7 [N 40°00.656’, W 119°12.545’]. Turn left (west) toward Nightingale mining district.

Mile 15.7 [N 40°00.633’, W 119°13.534’]. Stop 7. This is the heart of the Nightingale district. Discovered in 1917, tungsten was mined here during World Wars I and II and the Korean War, and mining ceased in 1956. Do not get close to or go into any of the shafts, adits, or glory holes in this area. STAY OUT AND STAY ALIVE! There are good samples to find safely on the mine dumps.

Scheelite, $CaWO_4$, is the primary ore mineral for tungsten, which is used to make **tough** tools composed of tungsten carbide and high-strength steel. In the Nightingale district, scheelite occurs in skarn (also called tactite or contact-metamorphosed limestone) along the contact between Cretaceous granodiorite and Triassic-Jurassic limestone. Scheelite fluoresces a bright bluish white when stimulated with ultraviolet light, making fluorescence an excellent exploration tool for this mineral (at night). Watch out for scorpions and rattlesnake rattles, which also fluoresce.

Figure 20. Photographs of garnet- and epidote-bearing samples from the Nightingale district: (a) left (in regular light), (b) right (in short-wave ultraviolet light).

The main minerals in the skarn in the Nightingale district are epidote, ($Ca_2(Fe,Al)_3(SiO_4)_3(OH)$), quartz, calcite, and garnet. Garnets in this geological environment are typically in the solid solution series between the end-member compositions of grossular ($Ca_3Al_2(SiO_4)_3$) and andradite ($Ca_3Fe_2(SiO_4)_3$) with lesser quantities of almandine ($Fe_3Al_2(SiO_4)_3$), pyrope ($Mg_3Al_2(SiO_4)_3$), or spessartine ($Mn_3Al_2(SiO_4)_3$). Hydrothermal fluids from the crystallizing granodiorite introduced W, Fe, Al, and Si to the limestones in the wall rock of the intrusion. The Ca in the scheelite, epidote, and garnet came from the original limestone. The garnets here are red. Epidote is green. Quartz, calcite, and scheelite are white, although some quartz here is clear. Quartz is hard (7 on the Mohs hardness scale); scheelite has intermediate hardness (4.5 to 5), and calcite is softer (3). Scheelite and calcite have cleavage, whereas quartz breaks on conchoidal fractures.

Reset your odometer to 0.0.

Mile 0.9 [~N 40°00.656', W 119°12.545']. Turn right (southwest) back along the road down Coyote Canyon, back to Nixon and Reno via the route we came or around Pyramid Lake to Sutcliffe and Pyramid Highway to Reno.

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Alternate route back to Reno via a 20-mile dirt road to Bradys Hot Springs and Interstate 80:
Rezero odometer at BLM sign back on the main dirt road south of the Nightingale mines.

0.3 Cross power line access road and under power lines.
5.8 Do not take a jeep trail that enters from the left .
7.2 Do not take a track to the left that goes up the hill to some prospects.
8.0 Bear right at fork where another road enters on the left.
GPS coordinates here are: N 39° 58.006', W119° 04.959'
8.7 Pull off on side road to right where you may walk or drive a short distance to the SW to a small diatomite quarry and prospect. The diatomite is overlain by a layer of gray sandstone. GPS coordinates here are:

N 39° 56.552', W119° 04.678'

Diatomite is a rock that is composed of tiny fossils of single-celled plants that thrived in an ancient lake that was here a few million years ago (long before Winnemucca Lake or Lake Lahontan), when the climate in Nevada was considerably wetter, in part because the Sierra Nevada had not yet risen on the west and blocked moisture from the Pacific Ocean as it does today. Diatomite is a versatile rock that is mined and used as an absorbent, in acoustical tile and pipe insulation, and to filter impurities from liquids in many industrial and environmental applications. As we approach Interstate 80 we will pass close by Moltan Materials diatomite plant where they mine an impure, lower grade diatomite used mainly to produce cat litter.

RETURN TO VEHICLES AND CONTINUE SOUTH.

9.2 The main dirt road that joins our road from the right is the haul road for trucks coming from Celite Corporation's Nightingale deposit, where a very pure high-grade diatomite is mined intermittently and processed at their plant in Fernley. Celite is a subsidiary of World Minerals Inc., the world's largest diatomite producer and a subsidiary of Imerys, a large French industrial minerals company.

10.1 Cross under power transmission line.

14.6 ROAD FORKS; STAY ON THE RIGHT FORK
GPS coordinates here are: N 39° 51.694', W119° 02.542'

19.2 Road ends at frontage road; turn right on frontage road.
GPS coordinates here are: N 39° 47.970', W119° 00.867'

19.8 Turn left over cattle guard, and if time permits, continue south under I-80 underpass to opposite frontage road by Brady's geothermal power plant and take a right and stop/park by sign and fenced-off steam pools.

The theme of National Earth Science Week this year is "Exploring Energy" and returning via this route will take us past a major Nevada geothermal power plant operating at Bradys Hot Springs along U.S. Highway I-80. These were the Emigrant Springs of the Forty-Mile Desert; some early travelers called it the "Spring of False Hope." Coming across the long desert stretch to the east, the oxen of the wagon trains could smell the water before reaching the springs and rushed forward to drink only to find the water scalding. Many livestock died and there was no forage at the springs for them either. Travelers had to collect water and wait for it to cool before it was usable. Later emigrants left water in casks to cool for those who followed. The hot springs were developed as a travelers resort and pools in the 1950s and 1960s, after which they were explored for geothermal power potential beginning seriously in the 1970s.

Many wells were drilled and engineering tests were done throughout the 1980s and finally, the Bradys double flash power plant came on line in 1992, producing 21 MW from a 186°C resource. The plant was purchased by ORMAT Nevada, Inc. in July 2001 and in 2002, Bradys added a 5-MW binary Ormat Energy Conversion unit (OEC) that uses pentane as the working fluid.

Bradys Hot Springs are located over an elongate thermal area of up to 20 km^2 that parallels the Bradys fault, a steeply dipping, north-northeast-striking fault with down-to-the-northwest normal displacement centered on this location. This normal fault has had recent movement, as it cuts spring sinter and alluvial fan deposits in the springs area and to the north. The geothermal production wells at Bradys (seven in 2002) produce from depths of 300 to 1,800 m in permeable zones in Tertiary volcanic pyroclastic rocks in the hanging wall of the Bradys fault.
Also near this exit, ConAgra Foods Incorporated/Gilroy Foods has been operating a plant that dries and processes onions using natural geothermal energy since 1978.

Take Interstate 80 back to Reno from here.

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If you opt for the return route back through Nixon via the route we came or around Pyramid Lake to Sutcliffe and Pyramid Highway to Reno, follow this log:

Mile 2.0 [N 39°59.886', W 119°13.245']. Crest of the hill. This was Stop 6.

Mile 5.7. Don't stop, but note the thinly bedded, light beige lake sediments to the right. These are probably Lake Lahontan sediments deposited near the time of its high stand approximately 13,000 years ago.

Mile 6.0 [N 39°57.750’, W 119°16.006’]. Continue straight ahead (west) on the main road. This was the turnoff to Stop 5.

Mile 8.2 [~N 39°56.888’, W 119°18.144’]. Merge with road coming in from the right. Continue on the main road to the southwest.

Mile 8.7 [~N 39°56.384’, W 119°18.415’]. Continue straight. The road to the left goes to the White Caps/Crosby mine area.

Mile 9.6 [N 39°55.877’, W 119°19.118’]. Continue straight. This was the turnoff to Stop 4.

Mile 10.1 [N 39°55.479’, W 119°19.471’]. Turn left onto secondary dirt road that follows the base of the mountain southwest to Nixon.

Mile 13.1. Stay on the road to the southwest as another road merges from the right.

Mile 13.9. Entering the Pyramid Lake Paiute Reservation. Note the 5-centimeter thin, white layer of ash in the outcrops of Lake Lahontan sediments to the left. This is ash that was probably erupted from one of the volcanoes in California or Oregon a few thousand years ago.

Mile 16.8. Turn left (south), onto the pavement of Route 447, in Nixon. Drive slowly through town.

Mile 17.3. Cross the Truckee River.

Mile 17.9. At the turnoff to Sutcliffe and the west side of Pyramid Lake you have two options. Turn right to go back to Reno by way of Route 446 and the Pyramid Lake Road (Route 445) or continue straight, back to Wadsworth on Route 447.

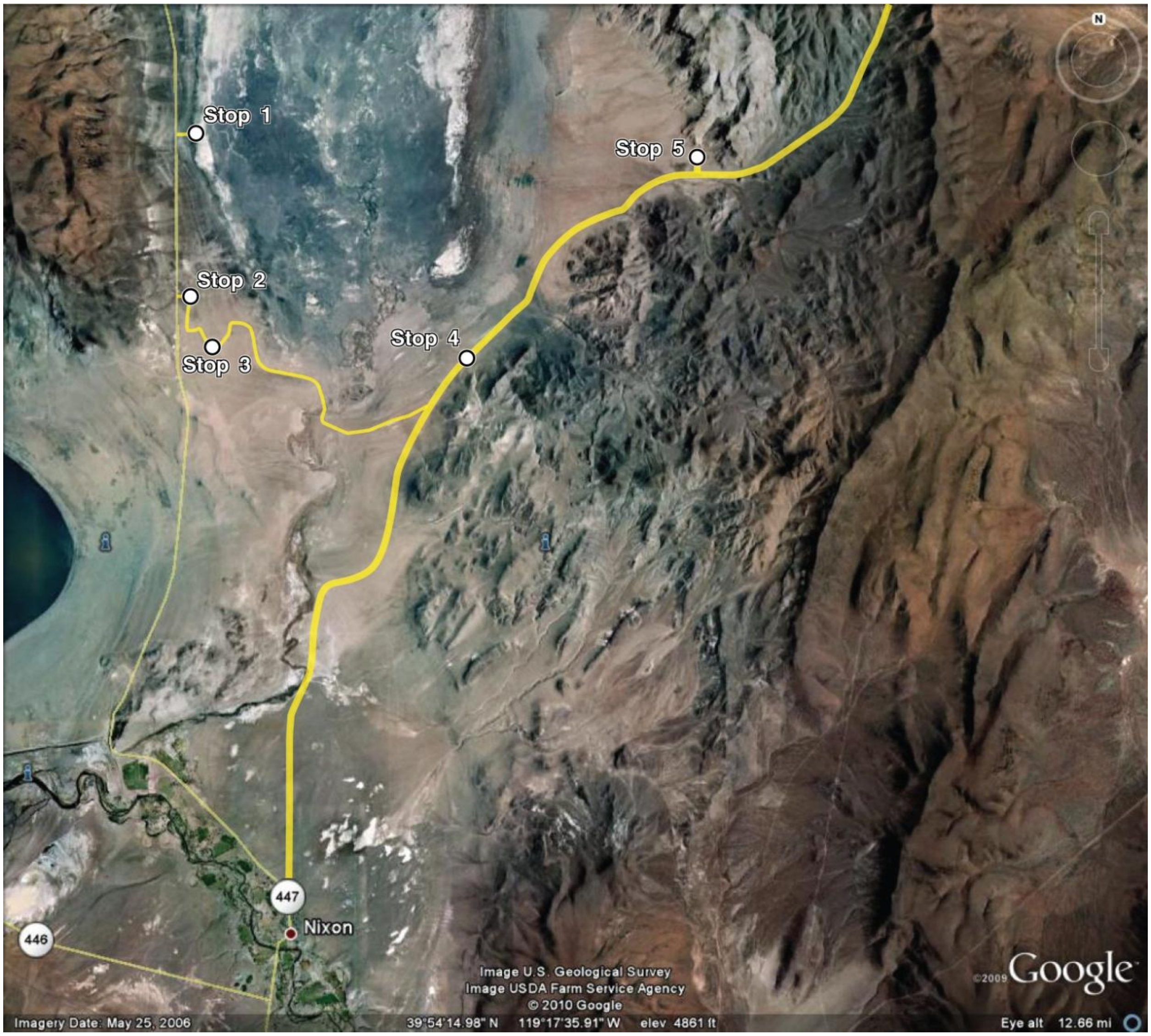

Figure 21. Aerial photograph showing the return route along the west side of the Truckee Range to Nixon.

Field trip guide prepared by J.G. Price and D.D. La Pointe, Nevada Bureau of Mines and Geology, August 2010.