Guide for the Earth Science Week Virtual Field Trip, October 17, 2020

Nevada Bureau of Mines and Geology

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Exploring the Hot Springs Mountains
A Virtual Tour for Earth Science Week, 2020

Red rocks in the Hot Springs Mountains

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Introduction

This year, Earth Science Week is celebrating the theme *Earth Materials in Our Lives*. In conjunction with the theme, the Nevada Bureau of Mines and Geology (NBMG) virtual field trip will take us on a tour of the natural history and geological resources in the northern Hot Springs Mountains of west-central Nevada. Our field trip will be a little different this year, as we aim to bring the outdoors and wonder of our unique state to you remotely, and socially distanced. This year we won't be following a road log, or touring sites in person, but we will be bringing some beautiful scenery, fascinating geology, and natural history directly to you, wherever you are. Thank you for being a part of our virtual Earth Science Week tour!

The Hot Springs Mountains are located in Churchill County to the east and northeast of Fernley. They are bounded to the west by the Fernley Sink and the Truckee Range while Hot Springs Flat and the Trinity Range lie to the north, across Interstate 80. The Fortymile Desert stretches far out to the east, full of alkali flats, sand dunes, and smaller hills of volcanic rock. The Hot Springs Mountains are a relatively subdued range (by Nevada standards) with multiple ridges rather than high mountains, as the name would have you believe. During the Pleistocene, this range was surrounded by a vast lake known as ancient Lake Lahontan—the Hot Springs Mountains were an island in this lake that extended across much of the western Great Basin.

Figure 1. Map showing the Hot Springs Mountains and surrounding locations, Desert and Leete mining districts, and geothermal power plants.

The range receives very little precipitation and is characterized by dry desert shrubs and grasses interspersed between volcanic rocks and eolian (wind-blown) sand. Despite the dryness, life can still be found here, but water ultimately determines who and what can survive in this harsh climate. Evidence of wildlife can be seen throughout the range—from burrows to tracks in the sand—if you know where to look.

The Hot Springs Mountains also contain an abundance of natural resources, including abandoned gold and silver mines, geothermal energy resources, diatomite, and salt. The Bradys Geothermal Area is situated on the northwestern side of the range and is home to one of several Ormat geothermal power plants statewide. The Desert Peak geothermal plant, also operated by Ormat, is located in the central portion of the range. The Desert Queen area contains another geothermal system that has yet to be developed (Faulds et al., 2010). Gold and silver mining took place in the northeastern part of the range, while the Eagle Salt Works is located on the western side of the range. We will explore the geothermal resources and mining history of this area later on.

Figure 2. Faults cutting the southern edge of Parran mesa (eastern Hot Springs Mountains), as marked by offset of the capping 7.5-million-year-old ash-flow tuff, which is one of the youngest ash-flow tuffs in the region. Photo by Jim Faulds.

Figure 3. Diorite outcrop in the Desert Queen area. Photo by Jim Faulds.

Rocks and Geology

The Hot Springs Mountains are primarily composed of basaltic and andesitic rocks of late Oligocene to late Miocene age that are broken up by many tilted fault blocks. The fault blocks are generally gently to moderately tilted and trend north-northeast. They are bounded by multiple normal faults that strike north-northeast and accommodate extension of the crust in the horizontal dimension (Faulds et al., 2010, 2017). Sedimentary deposits of the same age can also be found here.

These volcanic and sedimentary rocks overlie Mesozoic metamorphic and igneous basement rocks (Faulds et al., 2010). In the northern part of the range, near the Desert mining district, an intrusion of diorite of probable Jurassic age is overlain by some andesitic and rhyolitic rocks (Willden and Speed, 1974). Desert Peak, also located in the northern part of the range, is the core of an old volcano that was active during the late Miocene, about 8.9 million years ago.

The volcanic rocks that compose much of the range were primarily derived from the ancestral Cascade arc that contributed to abundant volcanic activity in the area millions of years ago. The ancestral Cascade volcanic arc began forming during the early Miocene (Busby et al., 2008), as the dense oceanic Farallon plate was subducting beneath the

western margin of the less dense continental North American plate (present day western Nevada and eastern California).

Figure 4. Block diagram of a subduction zone showing compressional tectonic forces that cause rocks and land masses to move together (graphic: NBMG).

This subduction and subsequent melting in the upper mantle above the subducting oceanic plate resulted in the formation of a volcanic arc, comparable to the present-day Cascade volcanoes of northern California, Oregon, Washington, and southern British Columbia. The oceanic Farallon plate has since subducted beneath the North American plate, leaving the Juan de Fuca plate to the north and the Cocos plate to the south. These two plates are now separated by a transform plate boundary you may have heard of: the San Andreas Fault. To learn more about plate tectonics, refer to the presentation *Plate Tectonics, Faults, and Folding—An Introduction to the Structure of the Earth, Crustal Movement, and Associated Land Forms* (https://arcg.is/0fqjHa).

Figure 5. Large pumice fragments in the basal part of the 7.5-million-year-old tuff that caps Parran mesa in the eastern part of the Hot Springs Mountains. Photo by Jim Faulds.

Geologists have identified many different rock units in the northern Hot Springs Mountains and mapped the Desert Peak quadrangle and the area surrounding the Bradys geothermal area in great detail. This region continues to be explored and mapped today. Both the "Preliminary geologic map of the Desert Peak quadrangle" and the "Preliminary geologic map of the Bradys geothermal area" are available for free download from NBMG and contain cross sections, geothermal well locations, and over 100 different geologic units. Some of the more prominent geologic units in the area include older aphanitic basalt lavas, basaltic andesite lavas, a variety of tuffaceous rocks, and silicified siltstone and diatomite units (Faulds et al., 2012; Faulds et al., 2017).

Figure 6. A portion of the geologic map of the Desert Peak quadrangle (Faulds et al., 2012).

Many of the rocks exposed in the area are covered with desert varnish, making them appear dark and glossy, similar to other rocks found around the Fortymile Desert. Desert varnish is commonly seen in arid regions and forms a thin rust-to-black coating on exposed rock surfaces. The varnish is composed primarily of manganese (Mn) and iron (Fe), but can contain clay minerals, oxides, or other trace elements (Encyclopedia Britannica). Microorganisms that live on the rock surface take manganese from their surrounding environment, oxidize it, and cement it to the rock surfaces. Desert varnish takes thousands of years to accumulate and commonly acted as a canvas for Native Americans to carve petroglyphs (National Park Service). Such petroglyphs can be seen to the southeast, across the Lahontan Valley at Grimes Point Archaeological Site.

Figure 7. Chartreuse and rust-colored lichen and desert varnish cover volcanic boulders. Photo by Jack Hursh.

Figure 8. Ancient Lake Lahontan Shorelines can be seen on many of the lower-lying hills in the area. Photo by Jim Faulds.

During the Pleistocene, the Hot Springs Mountains were an island in ancient Lake Lahontan, a glacial lake that filled and connected many basins in the western Great Basin. Pyramid Lake, Walker Lake, and the Carson and Humboldt sinks are remnants of ancient Lake Lahontan. Evidence of shorelines can be seen on the lower elevations of the hills and ridges in the region and give a rough idea of the area that was underwater.

Figure 9. Sand dunes in the Hot Springs Mountains. Photo by Jack Hursh.

The shorelines may appear slightly uneven in places—this is a result of the deformation of the Earth due to the weight of the water in the lake depressing the land and the land rebounding when the lake dried out (Bills et al., 2007). The lake reached a highest stand (elevation 4369 ft; 1332 m) at about 15,700 years ago (dePolo et al., 2018). As the climate warmed, the ancient lake dried up leaving dry playas and lake beds behind. During wet years some of these playas and lake beds hold excess water for short periods, serving as a brief glimpse into a wetter past. Sand and sediment are another common sight in the Hot Springs Mountains. Wind-blown sand can be found in many places throughout the range and even accumulates as dunes in some areas.

Figure 10. Extent of glacial Lake Lahontan at its highstand from Benson (2004). Black areas show existing lakes, and gray areas show ephemeral lakes and sinks. Red lines indicate overflow points (sills) between subbasins (dePolo et al., 2018).

Figure 11. U.S. Geological Survey benchmark "Rocky". High point of the range. Photo by Jack Hursh.

Natural History and the California Trail

Topography

These high desert ridges range in elevation from 4000 to 5500 feet (1220 to 1680 m) and exhibit locally steep slopes, drainages that occasionally contain water after winter rainstorms or summer thunderstorms, canyons, and alluvial fans. The highest peak of the range is unnamed at 5513 ft (1680 m) and is located in the southern part of the range at 39.699517° N, -118.989167° W. Desert Peak (5365 ft; 1635 m) is one of the few named peaks and is the highest peak in the northern part of the Hot Springs Mountains near I-80.

Flora and Fauna

Despite the dryness, many plants and animals can be found in this area. Native grasses, Mormon tea (Ephedra nevadensis), winterfat (Krascheninnikovia lanata), and Basket evening primroses (Oenethera deltoides) are just some of the unique flora that can survive in this area. While many shrubs grow in the Hot Springs Mountains, no trees inhabit the range.

From small burrows to animal tracks in the sand, evidence of animals and reptiles can be seen if one looks closely. Coyotes, kangaroo rats, bats, owls and other raptors, snakes, lizards, and scorpions all call the area home. Some are easier to spot than others, while many critters stay hidden below the surface or under rocks and shrubs during the day.

Nevada jointfir (scientific name Ephedra nevadensis) is a native shrub found throughout much of the Great Basin. Nevada jointfir was used for medicine and food by native Americans and was brewed as tea by Mormon settlers, which is why this plant is commonly referred to as Mormon tea. Seeds were eaten by the Panamint and Owens Valley Paiute while the Moapa Paiute and Shoshone used tea brewed from the twigs to treat venereal diseases. The Shoshone also drank the tea to encourage urination and used ground up twigs to treat wounds (USDA PLANTS Database). According to the USDA, Nevada jointfir is considered to be toxic and should be used with caution.

Figure 12. Cones on a branch of Nevada jointfir. Photo credit: Joe Decruyenaere (https://www.flickr.com/people/38213125@N00).

The Nevada jointfir is a spreading shrub that can reach up to 4 feet (1.2 meters). It has no leaves and exhibits jointed, evergreen stems, or twigs. It is primarily dioecious (having distinct male and female individual plants), and if there is enough moisture in the

soil, the plants will produce cones in the spring months. Pollination is driven by wind, and the plant produces seeds, which are carried off by small mammals and deposited in shallow seed caches. The Nevada jointfir roots are woody and can grow up to 6.5 feet (2 meters) in depth, which may spread laterally and produce other plants (Anderson, 2004). Habitat is varied throughout the Great Basin and can be found on slopes, ridgetops, and floodplains between ~2800 and 7000 feet (~853 and 2130 m) in elevation. The plant has a high saline tolerance and is commonly found along the edges of salt deserts and playas (Anderson, 2004).

The basket evening primrose (scientific name Oenothera deltoides) is one of the more spectacular wildflowers of the Great Basin. This beautiful, short-blooming annual is known by many other names, including birdcage evening primrose, dune primrose, devil's lantern, and lion-in-a-cage (Blackwell, 2006). The basket evening primrose grows on sandy dunes and flats up to an elevation of 5000 feet (1524 meters) and is commonly seen blooming in the mid-to-late spring months around Pyramid Lake and other sandy locations in western Nevada.

As the name suggests, the basket evening primrose flowers begin to open in the late afternoon or evening. The 4-petaled flowers are large (1.5–2.5 in; 3.8–6.4 cm) and white, with yellow centers. The bright white, fragrant flowers fade to a pinkish-lavender color in the morning (Blackwell, 2006). When the basket evening primrose dies back, the outer stems dry out and curl upward and inward, leaving a basket or birdcage around the seed pod.

Figure 13. Basket evening primrose in full bloom. Photo by Stan Shebs; https://commons.wikimedia.org/wiki/User:Stan_Shebs (left). Seed pod of the basket evening primrose. Photo by Jack Hursh (right).

Purple Nama (Nama aretioides) is a beautiful, reddish-purple ground-covering annual that is found throughout west central Nevada in sandy to gravely washes and flats up to an elevation of 6500 feet (1980 m). The small, 5-petal flowers with yellow centers grow close to the ground above narrow, fuzzy leaves (Blackwell, 2006). Purple Nama blooms from May through June and creates a brightly colored, eye-catching carpet that can be seen covering some of the hillsides in the Hot Springs Mountains.

Figure 14. Many desert shrubs remain dormant during dry periods and spring to life after periods of rain. The Hot Springs Mountains come to life with purple Nama and other wildflowers following the wet winter of 2004–2005. Photo by Jim Faulds (left). A type of Chorizanthe growing among rocks near the Desert Queen Mine. Photo by Rachel Micander (right).

Chorizanthe, known more commonly as spineflowers, are a genus of plants in the buckwheat family and are hard to miss with their bright green, spiny appearance. They are very small and can be easily covered by rocks and debris. Desiccated and dead Chorizanthe are brown to black in color and blend into their surroundings.

Despite the dryness, there is water here. From small streams that run from geothermal springs and rare snowmelt, to streams that come to life following seasonal thunderstorms, this water gives life to its surroundings.

Wildlife have adapted to living within this high desert environment. When temperatures become extreme, either hot or cold, many critters will spend much of their time in underground burrows. Mammals, reptiles, and insects alike will all use burrows to protect themselves from the harsh environment they call home (U.S. Fish & Wildlife Service). Use caution when exploring their habitat. What may appear to be a small hole in the sand could be the front door to an extensive burrow, winding below the sand and dirt.

Figure 15. Above: animal tracks in the sand. Whose tracks can you identify? Right: a stream flows through sandy soils. Photos by Jack Hursh.

Figure 16. Animal burrow in the sand. Who lives here (left)? A moth lands on a volcanic rock (right). Photos by Jack Hursh.

Among some of the wildlife that can be found here is the great horned owl. The great horned owl (Bubo virginianus) is a large bird of prey that ranges in height from 18 to 25 inches (~46 to 64 cm) and has a wingspan of up to 6 feet (1.8 m)! They generally display various shades of brown feathers with a prominent white throat and have large ear tufts, which resemble horns, spaced apart on their heads. Their eyes are strikingly bright yellow and quite large. The great horned owl lives throughout North America and can be found in a variety of landscapes including desert mountains, forests, and even urban areas (Peterson, 1961). They nest in open areas or trees and commonly use nests that other birds have built since they do not build their own. These raptors are nocturnal and roost during the day among rocks or in trees. They

Figure 17. A great horned owl perches on a boulder. Photo by Jack Hursh.

are territorial birds who remain solitary except when breeding and nesting with their mate. Great horned owls feed primarily on small rodents, which they hunt by perching on trees, rocky outcrops, or cliffs and listening for signs of prey. Once they locate their prey, they will silently swoop down, catching their meal with their large talons (Nevada Department of Wildlife).

Some fun facts about the great horned owl, courtesy of the Nevada Department of Wildlife: great horned owls are Nevada's largest nocturnal bird of prey. If the great horned owl was the size of a human, its eyes would be as big as oranges. Great horned owls can locate their prey solely by sound.

The California Trail and Recent History

Figure 18. Steam escapes from a fumarole at Bradys Hot Springs (left). Looking across the Fortymile Desert toward the Mopung Hills (right). Photos by Jim Faulds.

The Fortymile Desert was an incredibly long, dry, and challenging section of the California Trail. Emigrants traveling across the country often traversed this section in August, hoping to make it over the Sierra Nevada before snowfall. The Fortymile Desert extends from the end of the Humboldt River, in the Humboldt Sink, to the Carson River or the Truckee River. In the Humboldt Sink, there was a fork in the California Trail. Emigrants could choose the Carson route or the Truckee route, but each spur resulted in the same distance traveled before reaching fresh water (California Trail Interpretive Center). Emigrants wrote extensively about this dangerous stretch of trail, many noting the extreme heat, dead animal carcasses, abandoned wagons, and grave markers seen along the trail (Kreutzer, 2012).

Bradys Hot Springs, located at the base of the northwestern portion of the Hot Springs Mountains, were once known as the Emigrant Springs of the Fortymile Desert. To some emigrants, they were called the "Spring of False Hope", because the water at this location was so hot. Oxen of the wagon trains traveling across the Fortymile Desert could smell the water of the hot springs before reaching them. As they approached the springs, they rushed forward to drink, but the water was scalding hot and undrinkable. Many livestock died here, and travelers had to collect water and wait for it to cool before being able to drink. Later on, emigrants left water in casks to cool for those who followed (Price and LaPointe, 2010).

The Fortymile Desert portion of the California Trail was used from 1843 until about 1869. During those years over 10,000 animals died crossing this stretch and over 950 people lost their lives prior to 1850. Most emigrants traveled this section at night, often setting fire to abandoned wagons to light their way. In total, it took about two days for travelers to make it across the Fortymile Desert to reach either the fresh water of the Carson River or Truckee River (California Trail Interpretive Center; https://www.californiatrailcenter.org/40-mile-desert/).

In the 1950s and 1960s, a travelers resort was developed at the hot springs. Soon after, the area was explored for geothermal power potential, which began seriously in the 1970s (Price and LaPointe, 2010).

Today, the area surrounding these hot springs is home to an onion dehydration plant and the Bradys geothermal plant, which we will discuss later on. On some mornings, you can smell the sulfur of the hot springs mixed in with dehydrating onions, which combine to produce an aroma that rather resembles the smell of a fresh-cooked omelet. The dehydration plant, owned by Olam International, dries and processes onions using the geothermal energy. This plant was previously owned and operated by ConAgra Foods/Gilroy Foods and has been in operation since 1978 (Price and LaPointe, 2010).

Geothermal Energy

Nevada has more geothermal resources than any other state and is second only in geothermal production to California. The state is home to an abundance of hot springs and other geothermal features such as sinter, travertine, tufa, fumaroles (openings in the Earth's surface that emit steam and other gases), and mud pots. In the northern Hot Spring Mountains alone there are three geothermal systems, and springs and fumaroles can be found at Bradys Hot Springs. The three closely spaced and relatively high-temperature geothermal systems in the northern Hot Springs Mountains epitomize the abundance of geothermal resources in the Great Basin.

Figure 19. Geothermal areas in the Hot Springs Mountains. BR, Bradys geothermal area; BFZ, Bradys fault zone; DP, Desert Peak geothermal area; DQ, Desert Queen geothermal area; DQB, Desert Queen basin; DQF, Desert Queen fault zone; HSFB, Hot Springs Flat basin; NHSM, northern Hot Springs Mountains; RRF, Rhyolite Ridge fault zone; SA, small geothermal anomaly (Faulds et al., 2010).

The three geothermal systems in the northern Hot Springs Mountains occur along separate north-northeast striking normal-fault zones, and each is associated with a distinct geothermal anomaly (Faulds

et al., 2010). The Bradys geothermal system is located along the western flank of the range, the Desert Peak geothermal system is in the north-central part of the range, while the Desert Queen geothermal system is located in the eastern part of the range east of the Desert mining district. Both Bradys and Desert Peak have operating geothermal power plants.

The hot springs in the Bradys geothermal field have been used for at least the past 150 years starting with emigrants crossing the Fortymile Desert. Later on, between 1930 and 1950, a resort and spa operated here. Geothermal exploration began in the 1950s and has continued off and on over the past several decades. The first power plant at Bradys began operating in 1992. Today, a combined dual flash and binary geothermal power plant has a total installed capacity of 26 MWe (Megawatts electric) (Faulds et al., 2017). When passing by the Bradys geothermal field, travelers on Interstate 80 will often see steam escaping from the ground on cooler days. The ground in many places is quite warm in this area, and reservoir temperatures were estimated to be between 356 and 379°F (180 and 193°C) at 3280 to 6560 feet (1000 to 2000 m) in depth by Benoit et al. (1982).

Figure 20. A portion of the geologic map of the Bradys geothermal area (Faulds et al., 2017).

While many geothermal features can be seen in the Bradys geothermal field, both Desert Peak and Desert Queen are blind geothermal systems. A blind geothermal system is a system where there are no surface indications of hot water (hot springs or fumaroles) and very few fossilized spring deposits (Faulds et al., 2010) such as sinter.

Figure 21. Steam rises from a well near the Desert Peak geothermal plant (left). A geothermal well near the Desert Peak geothermal plant (right). Photos by Jim Faulds.

The Desert Peak geothermal system has a reservoir temperature of 405°F (207°C) and powers two binary geothermal plants with a combined capacity of 26 MWe. This blind geothermal system displays some silicified sand of late Pleistocene age, located about 4300 feet (1310 m) west of the production wells. These sands were probably the result of outflow from a prehistoric spring into ancient Lake Lahontan (Faulds et al., 2010). This system was first identified by a drilling program in the 1970s (Benoit et al., 1982) and utilized two original production wells and one injection well in its first 30 years of operation. A drilling program in the late 2000s helped to increase production (Faulds et al., 2010).

Unlike Bradys and Desert Peak, the Desert Queen geothermal system is undeveloped and does not have a geothermal power plant. It is also a blind geothermal system, and no hot springs or fumaroles are present in the area (Faulds et al., 2010). The Desert Queen geothermal system was identified by temperature gradient drilling in 1974 that showed a thermal aquifer at about 230 feet (70 m) in depth. Temperatures were observed as high as 284° F (140° C) in shallow gradient holes (Faulds et al., 2010). In late 2006, another survey found a strong temperature anomaly of 108° F (42° C) at 6.6 feet (2 m) in depth (Coolbaugh et al., 2007).

Figure 22. Well-exposed fault surface with slickenlines showing direction of movement along a segment of the Desert Queen fault (left). Tufa growth observed in the flats east of the Desert Queen geothermal area (right). Photos by Jim Faulds.

Mining History

Figure 23. An abandoned mine near the Desert Queen Mine, Desert mining district. While this old mine may look interesting, there are many dangers associated with abandoned mines. Stay out and stay alive! Photo by Rachel Micander.

Mining in the area occurred mainly in the Desert mining district located in the northeastern part of the range situated east-northeast of Desert Peak, one of the tallest peaks in the range at 5365 feet (1635 m). The Desert Queen and Fallon Eagle abandoned mines are both located in this mining district.

The Desert Queen and Fallon Eagle mines are located just south of a prominent hill called Cinnabar Hill. Commodities mined here included gold, silver, and mercury, with many adits (tunnels), shafts, prospect pits, and tailings piles still visible in the area today. The Desert Queen Mine may have been discovered as early as 1849, but mining did not begin in earnest until 1863. At least three mills were constructed in the area (Vanderburg, 1940). Prior to active mining, most explorers were entering the range in search of water, not minerals, during their grueling travels across the Fortymile Desert. Production in this district was fairly minor, with reported productions for 1883–1884 and 1938–1939 amounting to just over $25,000 (nearly $132,000 today). Production since 1939 was minimal and inconsistent, and there has been no recorded production in the district since 1951 (Willden and Speed, 1974).

The ore deposits at the Desert Queen, Fallon Eagle, and a third unnamed mine were located in quartz veins within strongly jointed diorite rocks. The diorite is overlain by silicified sedimentary and volcanic rocks, which are in turn unconformably overlain by a series of basalt lava flows and tuffs, with interspersed sedimentary deposits. Rocks in the district are displaced by several normal faults, which all appear to be younger than the mineralization (Willden and Speed, 1974). The three mines in the district were rather extensive during mining operations based on the size of tailings piles still visible and old maps of the workings.

During the cold war, a handful of these now abandoned mines were surveyed for use as fallout shelters, should the United States ever come under nuclear attack. Records of these surveys have been used in recent years to determine the extent of the mines and potential for suitable bat habitat.

There are over 300,000 abandoned mine land features scattered across the state of Nevada, many of which pose significant risk to human and animal life. Hazards associated with abandoned mines include falling, cave-ins, explosives, poisonous or deadly animals (rattlesnakes and cougars), rotten timbers, water, and bad air. The Nevada Division of Minerals (NDOM) runs the state's Abandoned Mine Lands (AML) Program and has worked toward cataloging and securing these hazards since the late 1980s. According to NDOM, there have been zero reported injuries or fatalities associated with AML features since 2013; over 100,000 historic mining features (both hazardous and not) have been inventoried; and they have cataloged over 23,500 hazardous AML features with an 80% securing rate. In 2020 alone, NDOM had inventoried 213 AML sites and secured 480 hazards (statistics courtesy of Sean Derby, Chief of the Abandoned Mine Lands Program, NDOM and current as of October 1, 2020). NDOM works with other state and federal agencies in Nevada to catalog and secure these old mines, and they hire interns each summer to assist with inventory and securing. Some of these closures have taken place in the Desert

mining district and include bat gates, which promote the continued use of an abandoned mine for bat habitat but keep people from entering and disturbing sensitive habitat and putting important bat colonies at risk. If you would like to learn more about the importance of bats and the challenges they face, please refer to the 2019 Earth Science Week field trip guide, "Lode and Lode and Behold! Geology and Natural Resources of the Truckee Meadows and Virginia City" (https://pubs.nbmg.unr.edu/Lode-and-behold-p/e065.htm).

Figure 24. Looking across the salt flats towards the Truckee Range. Photo by Jack Hursh.

The Leete mining district is located along Interstate 80 on the western margins of the Hot Springs Mountains. Commodities mined here included borates and sodium chloride (salt), which may have been the first non-metallic mineral mined in Nevada. The district was active between 1871 and 1913 (Tingley, 1998). The Leete mining district included the Eagle Salt Works, a 5000-acre operation that was built by Benjamin Franklin Leete in 1870, and quickly became the primary source of salt for the mills operating on the Comstock (Rigby, 1999). Salt was mined on many lakebeds and playas throughout the state and shipped to areas where silver and gold mining and processing was taking place. Mill operators believed that the addition of salt to a slurry of ground ore, water, mercury, copper sulfate or sulfuric acid, helped precipitate the silver and gold (Rigby, 1999). Prior to salt production in Nevada, salt was transported over the Sierra Nevada from Alameda, California. This salt, transported by boat on the Sacramento River from Alameda to Sacramento and then by wagon to the Comstock milling operations, cost between $120 and $180 per ton (Browne and Taylor, 1867). The location of the Eagle Salt Works deposits were an ideal source for an alternative to the California sourced salt based on the proximity to the newly constructed Central Pacific Railroad. Benjamin Franklin Leete began shipping salt by train to Reno, which was then transported to the Comstock by wagon. In 1872, the Virginia and Truckee Railroad was completed making it possible for Leete to ship most of the salt mined at the Eagle Salt Works by rail directly to consumers on the Comstock (Rigby, 1999).

Figure 25. Faulted diatomite deposits in the Hot Springs Mountains. Rock hammer for scale. Photo by Jim Faulds.

Large diatomite deposits also occur along the northwest side of the range in late Miocene lakebeds. The region was much wetter during this time with abundant volcanoes that may have resembled the present-day Cascade Mountains in Oregon and Washington. Diatoms, which compose the rock diatomite, are microscopic critters that live in calm freshwater environments. When these creatures die, their skeletons sink to the bottom of the freshwater body they inhabited. Over time, their skeletons (which are composed of silica) accumulate and solidify into diatomite. Today, many diatomite deposits are mined in the Truckee River Canyon east of Reno and other areas farther east. Nevada is the second leading producer of diatomite in the nation. Because of its porous nature, diatomite is used to filter beer and wine and used to produce potable water in some water filtration systems. It is also used as a filler in many products from soap and detergents to paper.

Summary and Conclusions

If you would like to venture out and explore the many wonders of the Hot Springs Mountains in person, we welcome you to hop into your off-road capable vehicle and grab some topographic maps, a spare tire (or two), a picnic lunch, a GPS and compass and head on out to explore your public lands. Topographic maps are available for purchase from the NBMG Publication Sales Office. Cell phone coverage is spotty at best in this part of the state, and we have always found paper maps to be worth their weight in gold. To help get you started, the quadrangles in this area include Parran, Desert Peak, Hot Springs Flat, Eagle Rock, Soda Lake NW, and Upsal Hogback. For a topographic map index complete with links to purchase 1:250,000, 1:100,000, 1:62,500, and 1:24,000 index maps in Nevada, check out the NBMG topographic map web application here https://gisweb.unr.edu/topomaps/. Topographic maps are also available for purchase from the NBMG Publication Sales Office (https://pubs.nbmg.unr.edu/category-s/1845.htm). As always, please exercise caution when exploring off highway areas and respect the landscape, wildlife, artifacts, and others out enjoying nature. Remember to stay on developed dirt roads and trails, and never park on dry grass or brush.

Thank you for joining us on this virtual field trip and if you have questions about the rocks, geology, or the natural resources that we covered in this guide, we are always happy to answer your questions!

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