



Guide for the Earth Science Week Field Trip, October 11 and 12, 2014
Nevada Bureau of Mines and Geology Educational Series E-56

Carson Rocks!

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2014

A Sesquicentennial Celebration of some of our Capital City's Geological High Points.

In recognition of Nevada's 150th birthday, Nevada Bureau of Mines and Geology (NBMG) is moving its 17th annual Earth Science Week public field trip south in 2014 to the hills around Carson City—to explore some of the geological features that have made this such an exciting place for people to live and that continue to shape its development today. The theme of National Earth Science Week 2014 is “Earth's Connected Systems” and participants are encouraged to explore the interactions between Earth's geosphere, hydrosphere, atmosphere, and biosphere as we explore several sites on our travels today. More information on National Earth Science Week is available at this website: <http://www.earthsciweek.org/materials/index.html>

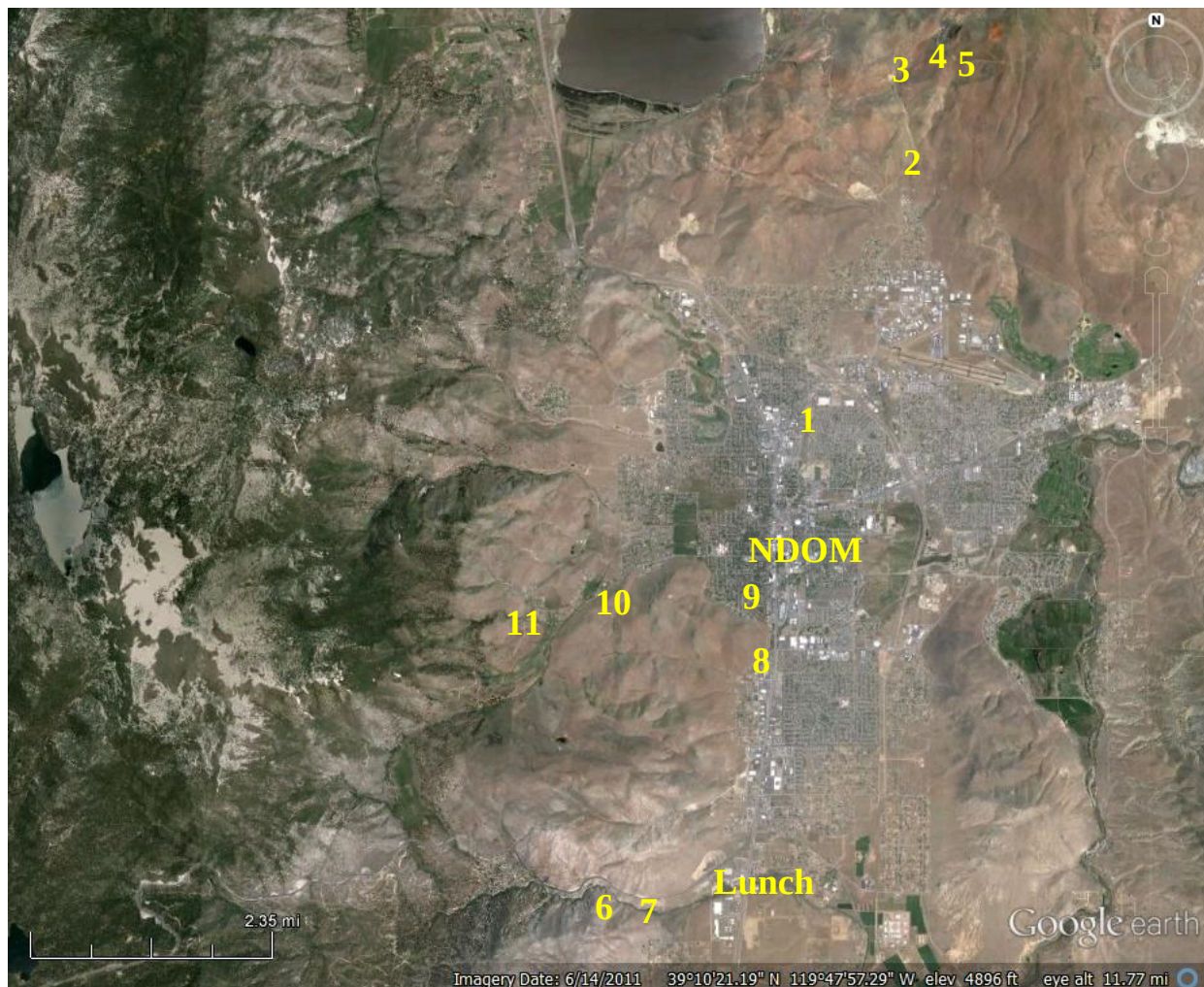
This year NBMG is partnering with Dr. Winnie Kortemeier of Western Nevada College, who has offered her expertise in the selection of sites of geologic interest around the Carson area and in the compilation of this trip guide, and also with the Nevada Division of Minerals, who have opened their office on the weekend for parking and use of facilities by participants. Some Nevada Division of Minerals geologic staff members are also participating in the field trip and are available to answer questions.

We will travel from central Carson City to several sites in and around its outskirts and discuss a wide variety of topics such as earthquake and volcanic hazards, watersheds, water use and planning, mineral resources, weathering and erosion, rockfall hazards, bedrock geology, and geologic history and how these topics have impacted human history in Nevada in general, and regional development in the Carson City area.

Along the way, we will visit several sites where we can examine and collect a variety of interesting rocks that help earth scientists explain the geologic history of the area. The field trip is designed to offer a high-quality field-based Earth science educational

experience to all, and it should provide any participating teachers with an array of potential venues for class field trips. Materials and ideas will be shared on how to facilitate field-based learning for K-12 classes.

Bring your own high-clearance vehicle (or arrange to carpool with someone else to reduce the number of vehicles in limited parking areas), lunch, sunscreen, hat, first-aid kit, and plenty of water. Field trip participants should meet at 0800 in the parking lot of the Nevada Division of Minerals (NDOM) Offices at 400 West King Street in Carson City. The building houses their public service and operations office, where you can park today. The field trip will leave NDOM at 0830. The general route of the field trip is shown on the accompanying map with the stops indicated. Total distance traveled by vehicle from starting point at Nevada Division of Minerals Office is about 35 miles round trip. If traveling from Reno, the entire round trip mileage will be about 100 miles. Mileages given are cumulative. Vehicle odometers may differ, so keep track of landmarks and lead vehicles.



Google Earth image of field trip stops around Carson City.

Some of the driving will be slow, so make sure you have plenty of gasoline. You can use this guide to take the trip on your own at another time, if you can't join us this year. There will be easy to moderate hiking, some uphill, at each stop – all will return to same parking spot so if too strenuous, you can walk slowly. Stops will include the following:

- Stop 1. Lone Mountain trail in Carson City: collect epidote, quartz, and garnets.
- Stop 2. Goni Road: collect aplite in weathered granodiorite
- Stop 3. Goni Road: Nine Hill Tuff, collect pink rhyolite with pumice fragments and crystal-lined cavities
- Stop 4. Cinder Cone: collect scoria, basalt, volcanic bombs.
- Stop 5. Granodiorite overlain by basalt and Washoe Valley overlook.
- Fuji Park: Lunch Stop
- Stop 6. Clear Creek jointed granodiorite above range-front fault
- Stop 7. Clear Creek granitic sediments below range-front fault
- Stop 8. Carson City Visitors Center/Railroad Museum parking lot sag pond
- Stop 9. Minnesota St. urban fault scarp
- Stop 10. Kings Canyon Road prospect: collect magnetite, garnet, and quartz
- Stop 11. Kings Canyon trailhead: collect a variety of rocks: metavolcanics, schist, overlook of the Carson fault zone and Carson City.

Leave Parking lot of NDOM

Cumulative Miles

0.0 Turn left (north) on Division St. leaving the parking lot.

0.7 Turn right on Long St., cross North Carson St.

1.0 Turn left on Roop St.

1.9 **STOP 1.** Turn right on Northridge St. and immediately right into the parking lot at the NW end of Lone Mountain, a hill in Carson City with a hiking trail along its crest that will give us a good view of the surrounding area from which to discuss local general geology and an opportunity to collect some of the oldest basement bedrock exposed at the surface in this part of Nevada. Lone Mountain is a small expression of the Basin-and-Range topography that is prevalent across most of the State of Nevada. Of the three major types of faults (strike-slip, normal, and reverse or thrust faults), Nevada's active faulting is dominated by two (strike-slip faults and normal faults). The normal faults are largely responsible for the Basin-and-Range topography of Nevada; Lake Tahoe is the westernmost of these basins and a very deep one. Nevada is one of the most seismically active states in the U.S.—second only to California among the lower 48 states. Historically, we have experienced a magnitude 7 or greater earthquake about once every 30 years somewhere in Nevada. The last ones were in 1954 near Fallon. The Reno-Sparks-Carson City area ranks among the 30 urban centers in the nation with the highest potential earthquake loss, according to estimates by the Federal Emergency Management Agency (FEMA).

The north-south trending “normal”-type faults result from extensional (pulling apart) forces in the Earth's crust in this part of the continent. Geodesists at NBMG use satellites to precisely measure the amount of extension occurring as well as the amount of down-dropping of the basins relative to rising of the adjacent mountain ranges.

This extension has been going on for the last 6 to 10 million years or so and continues today; it is the cause of recurring earthquakes, which are monitored by the UNR Seismology Lab and other linked institutions. Throughout the tour today we will be noting the locations of Basin-and-Range faults around Eagle Valley on which these earthquakes have occurred and will continue to occur. We'll learn how you can recognize the faults. The Lone Mountain Fault is on the east (steepest) side of the hill where there were some swamps and low wetlands before fill was brought in to create a foundation for the newer construction you see in this area.

The rocks that have risen along the fault to form Lone Mountain are Mesozoic (Jurassic to Triassic) in age (refer to the geologic time bookmark provided) about 250 to 150 million years old and are metamorphosed mafic (dark) volcanic rocks. This is about the same age as the sedimentary rocks that enclose our state fossil, the Ichthyosaur, a few hundred miles farther southeast in western Nye County. The rocks on Lone Mountain, however, are strongly metamorphosed volcanic rocks changed by heat, pressure and hot fluids, probably several miles deep, now brought to the Earth's surface by tectonic forces along faults, with the rocks above them long since eroded away. Metamorphism also caused the formation of some interesting minerals we can look for today—walk along the trail to the south and you should see increasing amounts of the pistachio-green mineral epidote and dark-red to brown garnet as well as white quartz and black tourmaline in veins and along fracture surfaces in the metavolcanic rocks. The chemical formulas of these and other minerals that we will see today are listed in the glossary.

Return to vehicles, exit lot.

2.1 Turn right on Roop St.

2.4 Turn right on College Parkway. Go under I-580 freeway.

3.1 Turn left on Goni Road.

3.6 Cross Arrowhead Road and note in passing the piles of “lava rock” landscaping materials on the left ahead at the Cinderlite office. We will be visiting the source of these shortly. **Note also the 25 mph speed limit ahead!** Continue north on Goni Road.

5.2 At Goni Pit sign and gate at gravel pit entrance ahead, road takes a sharp right-hand turn. Continue on road to the right; do not enter the gravel pit.

5.8 **STOP 2.** Pull off to the far right side of the road and park. Exposed here in the road cut, aplite dikes (fine-grained light granitic rock) crisscross weathered granodiorite. This granodiorite is Cretaceous in age— about 100 million years old - the same as the core of the Sierra Nevada across the main valley extending to the north and south. We will get a closer look at fresher granodiorite later on in the day at Clear Creek. Granodiorite is a coarse-grained igneous rock that solidifies from magma (molten rock) deep in the Earth (several miles) and is typically composed of the light-colored minerals feldspar (both plagioclase and orthoclase) and quartz with much lesser percentages of the dark minerals amphibole and biotite (mica). In the late stages of magma

solidification, the outer shell of the granitic body cracked and the last bits of magma shot through the cracks and hardened quickly as these “dikes” of aplite—a finer grained version of granite without the dark minerals. Here the granite is so weathered that it is eroding easily into “DG” or decomposed granite, while the finer-grained aplite does not erode as easily.

As we continue to drive up the road, also note the heavier vegetation in areas of the valley to the right indicating springs, which often follow fault lines.

6.8 STOP 3. Pull off on right side of road in area of road cuts and knobby weathered outcrops of rhyolitic Miocene-age Nine-Hill Tuff. Briefly examine, discuss, and collect a sample of this volcanic rock named for Nine Hill which is just west of us. Here it is a pinkish gray moderately to densely welded silicified tuff that contains some flattened pumice fragments and a few phenocrysts (larger crystals) of sanidine, plagioclase, quartz, biotite, +/-clinopyroxene and some crystal-lined cavities. It is about 25 million years old—much younger than the granite but much older than the basalt lava flows and cinder cone that we will see next.

7.5 STOP 4. Pull off on right in wide area below the gate to the main Cinderlite pits on the left— **do not enter the pits – dangerous area – unstable slopes!** Here you are essentially in a volcanic vent of one of the youngest volcanoes of the region. Although this cinder cone is extinct, similar volcanic systems like this one could still erupt in northern Nevada. These basaltic rocks are only about a million years old. Look at the volcanic material – it is basaltic in composition but very vesicular (holey) in texture because it was ejected rapidly from great depth allowing the compressed gases in the lava to expand on ejection and then the bubbles were “frozen” in the rock as it cooled in the air. Holey dark volcanic rock like this is called **scoria**. It may be black or red depending on how oxidized the iron content is. All volcanic ejecta that you pick up here is called **tephra**; look for volcanic “**bombs**” which are pieces of lava that acquired rounded form or markings as they flew through the air. Check the lava (and all rocks we examine) with your magnets for presence of magnetite. Collect rocks, return to vehicles and drive farther up the road.

7.8 STOP 5. Pull off the road onto the shoulder at the wide spot on the right, squeezing as many vehicles as possible without blocking the road to through traffic. Walk up to the granodiorite outcrop overlain by basalt on the opposite side of road, and walk to the overlook.

At the top of this old road cut the rocks represent a gap in time of about a hundred million years since the granodiorite is about one hundred million years old and the overlying basalt is about a million years old. Geologists call the contact between two rock types with a large gap in age an “unconformity.”

Walk to the overlook to the southwest. Here you can look west across Washoe Valley to Slide Mountain where the major active range-front fault system along which the Carson Range rises is apparent at the base of the mountains. As faulting progresses,

mountain front steepens, the slopes become unstable, and landslides occur; this is obvious on the slopes of Slide Mountain, which last had a massive landslide in 1983, but has also occurred elsewhere along the range. This is also the source of the debris flows and mudslides like those that have built up the large delta of coarse sediments over time at the mouths of Ophir and Davis Creeks near Bowers Mansion at the north end of Washoe Valley—a major recreational area.

The Global Positioning System (GPS) geodetic station on Slide Mountain is one of a series of high-precision instruments that are used to measure motion of the surface of the Earth, both horizontally and vertically. From data recorded at these stations we know that about 20 to 25% of the motion between the Pacific Plate and the North American Plate, most of which is accommodated on the San Andreas fault in California, is taking place on strike-slip faults in western Nevada and eastern California. In addition, this particular GPS station was a key to understanding an unusual swarm of small, deep earthquakes that occurred in 2003. Researchers from Nevada Seismological Laboratory and Nevada Bureau of Mines and Geology detected that Slide Mountain moved up and to the northeast approximately 1 centimeter during the earthquake swarm, implying that magma was injected in the lower crust near the state line at the north end of Lake Tahoe.

We are also standing almost exactly on the divide between the watersheds of two of the four major river systems in northern Nevada: The Truckee to the north and the Carson River to the south. (The other two are the Humboldt and the Walker Rivers). None of these rivers reaches the ocean; all end in terminal lakes or “sinks.” The Truckee ends in Pyramid Lake (except for water that is diverted by Derby Dam to the Fallon area for crop irrigation). The Carson River ends in Carson Sink.

Turn vehicles around and proceed back downhill, retracing route.

8.8 **STOP 5.** Pull off onto shoulder of road at wide spot below rhyolite knobs.

Return to vehicles and continue down Goni Road retracing our route. Our next stop will be Fuji Park on Clear Creek Road (opposite Costco) for lunch, since we may get separated in traffic.

12.5 Right on College Parkway

12.9 Left on I-580 South on-ramp.

15.9 Right on Fairview Drive.

17.0 Left on U.S. 395 (Carson St.)

19.4 Right on Clear Creek Road

19.6 Turn left into Fuji Park grounds, west end; park in dirt lot. **LUNCH STOP**

Return to vehicles after lunch, REZERO ODOMETERS and

0.0 Drive **LEFT (WEST)** on Clear Creek Road

1.3. **STOP 6.** When safe from oncoming traffic, make a U-turn and park along the wide shoulder on south side of road. Walk back uphill to outcrop of granitic rock on south side of road. Examine and discuss fresh granodiorite above the range-front fault, jointing, weathering, erosion. Return to vehicles and drive back down Clear Creek Road to east.

2.1 **STOP 7.** Turn left across traffic and up into dirt parking area off the road. Use hand lenses or magnifiers to examine sediments eroded here below range-front fault. Check for presence of magnetite in sediments. Discuss erosion, deposition. Return to vehicles and continue east along Clear Creek Road back down to the junction with US 395.

3.0 Turn left (north) on US 395.

5.2 **STOP 8.** Turn LEFT (west) at Fairview Drive at entrance to Nevada State Railroad Museum, turn right and park in first lot by Carson Visitors Center. The range-front fault passes just to the west of us along Curry Street and the railroad tracks. You can see Mesozoic metasedimentary/metavolcanic rocks overlain by much younger horizontal fairly well-lithified sedimentary rocks in the roadcuts along Curry St. above us but it's too dangerous to walk along there. The swampy well-vegetated area that parallels the railroad tracks here is a sag pond that has formed along the range-front fault; the porous fractured ground drops along the fault faster than natural drainage patterns can develop to take the water away into creeks, forming a swampy area, usually linear, along the fault. Return to vehicles and exit the museum lot.

5.4 Turn right (south) on US 395.

5.7 Turn right on Rhodes St. just before the Wells Fargo sign.

5.9 Turn right on Curry St. and drive north, past the roadcuts of vertically layered Mesozoic metasedimentary/metavolcanic rocks overlain by horizontal Quaternary sedimentary rocks just viewed from below, another unconformity.

6.8 Turn left on 10th St.

6.9 Turn right on Minnesota St. and park off to right for short urban walking stop.

7.0 **STOP 9.** Park on right side of street between about Ninth and Tenth Streets.

The hillside in the back yard of the houses on the west side of the street is mapped as a Quaternary age fault scarp. Carbon-14 dates on wood in the fault indicate that the last movement on the fault may have been about 300 years ago. About a mile to the north

the fault bends to the east and crosses North Carson Street at about the location of the current Quality Inn (Fleischmann St.). Note the large size of the cottonwood trees along the trend of the fault where the roots have a deep permeable zone to obtain water. Discuss issues of earthquake safety, emergency preparedness, zoning, etc. Return to vehicles and drive north to King St.

7.3 Turn left on King Street.

7.9 Name changes to Kings Canyon Road. From 8.2 to 8.5 miles, please note as we drive past the Ridgeline subdivision at the base of the steep slope on the left the many large boulders incorporated into the landscaping schemes; we will discuss them at the next stop.

8.5 **STOP 10. Watch oncoming traffic and carefully pull off on left** into gravel road pullout at base of hill and park. We will hike up a steep but short dirt road to an iron prospect area where we can collect nice specimens of magnetite and quartz vein material, some with garnet. We are very close to the contact zone between granodiorite and enclosing metamorphic country rocks. Such contact zones are places where hot magma and associated fluids often react with the enclosing rocks (often of a different chemical make-up) to form metallic mineral deposits. You will often find mines and prospects for mineral deposits located in the “contact aureoles” surrounding granitic bodies. This is an area where a small body of magnetite and minor garnet was prospected in the contact zone of the Sierra granodiorite and surrounding metasediments and metavolcanic rocks but was found to be subeconomic.

Return to vehicles and continue west (left) on Kings Canyon Road.

10.0 STOP 11. Park at Kings Canyon trailhead at end of the paved road. Here we are close to one splay of the range-front fault again and the cuts along the trail expose Mesozoic metasedimentary and metavolcanic rocks similar to those we saw exposed along the trail on Lone Mountain, although in this area the metamorphosed volcanic rocks include schists, flinty schists, and flaser schists, more micaceous metamorphic rocks than we have yet seen today. We are very close to the contact with the granodiorite, which you will see if you hike far enough up the trail. Often near contact zones between igneous rocks and their host rocks you find vein and contact metallic mineral deposits. Along the main trail are side trails to prospects where very minor copper minerals present.

References:

Bingler, E.C., 1977, Geologic map of the New Empire quadrangle: Nevada Bureau of Mines and Geology Map 59, scale 1: 24,000.

Henry, C.D., and Faulds, J.E., 2010, Ash-flow tuffs in the Nine Hill, Nevada, paleovalley and implications for tectonism and volcanism of the western Great Basin, USA: *Geosphere*, v. 6, p. 339-369. doi: 10.1130/GES00548.1

Henry, C.D., and Faulds, J.E., 2014, Geologic map of the Nine Hill paleovalley—Carson City and New Empire quadrangles, western Nevada: Nevada Bureau of Mines and Geology unpublished map.

Kortemeier, W., 2014, field notes, unpublished.

Moore, J.G., 1969, Geology and mineral deposits of Lyon, Douglas, and Ormsby counties, Nevada *with a section on* Industrial mineral deposits by N.L. Archbold: Nevada Bureau of Mines and Geology Bulletin 75, plate 1, scale 1:250,000.

Stewart, J.H., 1999, Geologic map of the Carson City 30 x 60 minute quadrangle, Nevada: Nevada Bureau of Mines and Geology Map 118, scale 1:100,000, 12 p.

Nevada Bureau of Mines and Geology (NBMG) has two offices: one a research office in the Scrugham Engineering-Mines Building on the University of Nevada, Reno campus (UNR) and the other in the Great Basin Science Sample and Records Library (GBSSRL) at 2175 Raggio Parkway, which houses a publication sales office where you can find topographic maps for the entire state as well as many publications dealing with Nevada geology. Please feel free to visit the GBSSRL during normal business hours (Tuesday-Friday, 8-3) and browse our maps and publications. NBMG is the state's geological survey. It resides within the College of Science at UNR but also serves as a statewide agency, conducting research on the geology, mineral deposits, and natural hazards throughout Nevada.

GLOSSARY

Geologic Time Scale for This Area

Era	Period	Epoch	
Cenozoic	Quaternary	Holocene:	11,700 years ago to present
		Pleistocene:	2.6 million to 11,700 years ago.
	Tertiary	Pliocene:	5.3 million to 2.6 million years ago
		Miocene:	23.0 to 5.3 million years ago
		Oligocene:	33.9 to 23.0 million years ago
		Eocene:	55.8 to 33.9 million years ago
		Paleocene:	65.5 to 55.8 million years ago
Mesozoic	Cretaceous		145 to 65.5 million years ago
	Jurassic		201 to 145 million years ago
	Triassic		251 to 201 million years ago
<i>(Older rocks are not found in this area)</i>			

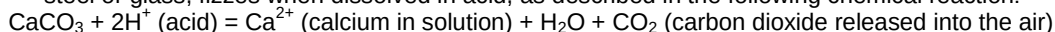
Minerals Found in This Area and their Chemical Formulas

Anorthoclase, a feldspar solid solution dominantly between the end members potassium feldspar, KAlSi_3O_8 , and albite, $\text{NaAlSi}_3\text{O}_8$, with lesser amounts of anorthite, $\text{CaAl}_2\text{Si}_2\text{O}_8$, clear to white; with cleavage

Apatite, $\text{Ca}_5(\text{PO}_4)_3(\text{OH},\text{F})$, occurs as small (less than 1 mm) crystals in many igneous rocks

Biotite, $\text{K}(\text{Mg},\text{Fe})_3\text{AlSi}_3\text{O}_{10}(\text{OH},\text{F})_2$, dark brown to black mica found here as tiny flakes

Calcite, CaCO_3 , generally white or clear, but sometimes black or other colors, rhombohedral cleavage, softer than steel or glass, fizzes when dissolved in acid, as described in the following chemical reaction:



Chalcedony, a fine-grained variety of quartz, SiO_2 , pale yellow and milky white

Chalcopryrite, CuFeS_2 , brass yellow, metallic, crystals resemble tetrahedrons, tarnishes iridescent

Chlorite, green, typically replacing other Fe-Mg minerals, $(\text{Fe}^{2+}, \text{Fe}^{3+}, \text{Al}, \text{Mg}, \text{Mn}^{2+})_{4-6}(\text{Si}, \text{Al})_4\text{O}_{10}(\text{OH}, \text{O})_8$

Clinopyroxene, $\text{Ca}(\text{Mg}, \text{Fe})\text{Si}_2\text{O}_6$, black or dark green, hard mineral common in basalt and andesite

Cryptomelane, $\text{K}(\text{Mn}^{4+}, \text{Mn}^{2+})_8\text{O}_{16}$, a black manganese oxide that commonly forms dendrites (branching crystals on a rock surface) – commonly mixed, as psilomelane, with romanechite and hollandite

Chrysocolla, $\text{CuSiO}_3 \cdot 2\text{H}_2\text{O}$, blue to blue-green, sticks to tongue

Epidote, $\text{Ca}_2(\text{Fe}^{3+}, \text{Al})_3(\text{SiO}_4)_3(\text{OH})$, pistachio-green mineral, often with prismatic crystals

Garnet, a group of minerals with the general formula $\text{A}_3\text{B}_2(\text{SiO}_4)_3$, where

A = Ca, Fe^{2+} , Mg, Mn^{2+} ; B = Al, Cr^{3+} , Fe^{3+} , Mn^{3+} . They are commonly red, brown, or green and form dodecahedral (12-sided) crystals.

Some of the more common garnets are represented by the end-member compositions of

Almandine, $\text{Fe}_3\text{Al}_2(\text{SiO}_4)_3$

Pyrope, $\text{Mg}_3\text{Al}_2(\text{SiO}_4)_3$

Grossular, $\text{Ca}_3\text{Al}_2(\text{SiO}_4)_3$

Andradite, $\text{Ca}_3\text{Fe}_2(\text{SiO}_4)_3$

Spessartine, $\text{Mn}_3\text{Al}_2(\text{SiO}_4)_3$

Goethite, FeOOH , orange, rust-colored mineral, usually coating other rocks

Hematite, Fe_2O_3 , red (giving some rocks a pink color); also occurs as small (generally less than 1 mm long) black crystals in igneous rocks, in a solid solution with ilmenite, FeTiO_3

Hollandite, $\text{Ba}(\text{Mn}^{4+}, \text{Mn}^{2+})_8\text{O}_{16}$, a black manganese oxide that commonly forms dendrites (branching crystals on a rock surface) – commonly mixed, as psilomelane, with romanechite and cryptomelane

Hornblende, $\text{Ca}_2(\text{Mg}, \text{Fe})_4\text{Al}(\text{Si}_7\text{Al})\text{O}_{22}(\text{OH}, \text{F})_2$, black prisms, common in many igneous rocks

Illite, $(K,H_3O^+)(Al,Mg,Fe)_2(Si,Al)_4O_{10}(OH)_2 \pm H_2O$, a white mica, clay-like mineral

Kaolinite, $Al_2Si_2O_5(OH)_4$, white clay mineral

Magnetite, Fe_3O_4 , black, magnetic, generally in a solid solution with ulvospinel, Fe_2TiO_4

Monazite, $CePO_4$, occurs as small (less than 1 mm) crystals in many igneous rocks, commonly contains many of the light rare earth elements in these rocks

Montmorillonite, $(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2 \cdot nH_2O$, part of the **smectite** group of clay minerals, also called **bentonite**, generally white or cream-colored but can be dark brown, red, or black, depending on impurities; because of its property of swelling when wet, it is used in drilling muds in oil fields

Muscovite, $KAl_3Si_3O_{10}(OH)_2$, white or clear mica

Orthoclase, a feldspar solid solution dominantly between the end members potassium feldspar, $KAlSi_3O_8$, and lesser albite, $NaAlSi_3O_8$, with small amounts of anorthite, $CaAl_2Si_2O_8$, generally pink, salmon, or white; with cleavage

Orthopyroxene, $Ca(Mg,Fe)Si_2O_6$, black or dark green, hard mineral common in basalt and andesite

Plagioclase, a feldspar solid solution dominantly between the end members albite, $NaAlSi_3O_8$, and anorthite, $CaAl_2Si_2O_8$, with lesser amounts of $KAlSi_3O_8$; with cleavage and striations from twinning within the crystals, clear when unaltered, commonly white when altered partially to clay minerals

Pyrite, FeS_2 , brassy, metallic mineral (fool's gold), which, when oxidized by rain water, produces sulfuric acid that alters minerals in most volcanic rocks to various clay minerals, including montmorillonite, smectite, kaolinite, and illite

Quartz, SiO_2 (silica), clear or white with conchoidal fractures (like glass, with no cleavage planes); scratches steel and glass

Romanechite, $BaMn^{2+}Mn^{4+}_8O_{16}(OH)_4$, a black manganese oxide that commonly forms dendrites (branching crystals on a rock surface) – commonly mixed, as psilomelane, with cryptomelane and hollandite

Sanidine, a feldspar solid solution dominantly between the end members potassium feldspar, $KAlSi_3O_8$, and lesser albite, $NaAlSi_3O_8$, with small amounts of anorthite, $CaAl_2Si_2O_8$, clear to white; with cleavage

Smectite, $(Ca/2,Li,Na)_{0.3}(Al,Cr^{3+},Cu^{2+},Fe^{2+},Fe^{3+},Li,Mg,Ni,Zn)_{2-3}(Al,Si)_4O_{10}(OH,F)_2 \cdot nH_2O$, a group of clay minerals that includes montmorillonite.

Titanite, $CaTiSiO_5$, occurs as small (less than 1 mm) crystals in many igneous rocks

Tourmaline, a group of minerals with the general formula $(Ca,K,Na)_3(Al,Fe^{2+},Fe^{3+},Li,Mg,Mn^{2+})_3(Al,Cr^{3+},Fe^{3+},V^{3+})_6(BO_3)_3Si_6O_{18}(O,OH,F)_4$ commonly found near one of the end-member compositions

Dravite	$NaMg_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$
Elbaite	$Na(Li,Al)_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$
Foite	$[(Fe^{2+}_2(Al,Fe^{3+}))Al_6(BO_3)_3Si_6O_{18}(OH)_4]$
Olenite	$Na(Al)_3Al_6(BO_3)_3Si_6O_{18}(O,OH)_4$
Schorl	$Na(Fe^{2+},Mn^{2+})_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$

Xenotime, YPO_4 , occurs as small (less than 1 mm) crystals in many igneous rocks, commonly contains many of the heavy rare earth elements in these rocks

Zircon, $ZrSiO_4$, occurs as small (less than 1 mm) crystals in many igneous rocks

Rock Types Found in This Area

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

<u>Intrusive</u>		<u>Extrusive</u>
Gabbro	=	Basalt
Diorite	=	Andesite
Granodiorite	=	Dacite
Granite	=	Rhyolite

Aplite here is a variety of granite with sugary texture; it contains mostly orthoclase, plagioclase, and quartz with few dark (iron- and magnesium-bearing) minerals. It occurs as dikes cutting the coarser-grained granodiorite.

Unconsolidated sediments in the area include **alluvium** (a mixture of clay, silt, sand, and gravel, generally deposited by streams), and **colluvium** (a mixture of soil material and rock fragments deposited by rainwash, sheetwash, or slow downslope creep on the sides of hills). Sediments classified by size of particles include **clay** (less than 1/256 mm in diameter), **silt** (1/256 to 1/16 mm), **sand** (1/16 to 2 mm), granule (2 to 4 mm), pebble (4 to 64 mm), cobble (64 to 256 mm), and boulder (greater than 256 mm). **Gravel** consists predominantly of rounded rock fragments larger than 2 mm.

Sedimentary rocks are consolidated sediments. With increasing grain size, these include, among other rock types, **claystone** (mudstone or shale), **siltstone**, **sandstone**, and **conglomerate (rounded fragments) and breccia (angular fragments)**.

Metamorphic rocks found in the area are typically called **metavolcanic or metasedimentary rocks**, if geologists can figure out what was metamorphosed. Other metamorphic rocks include schist (a platy rock with abundant mica – biotite and/or muscovite) and skarn, a rock formed at the contact with granitic rocks and commonly containing garnet.