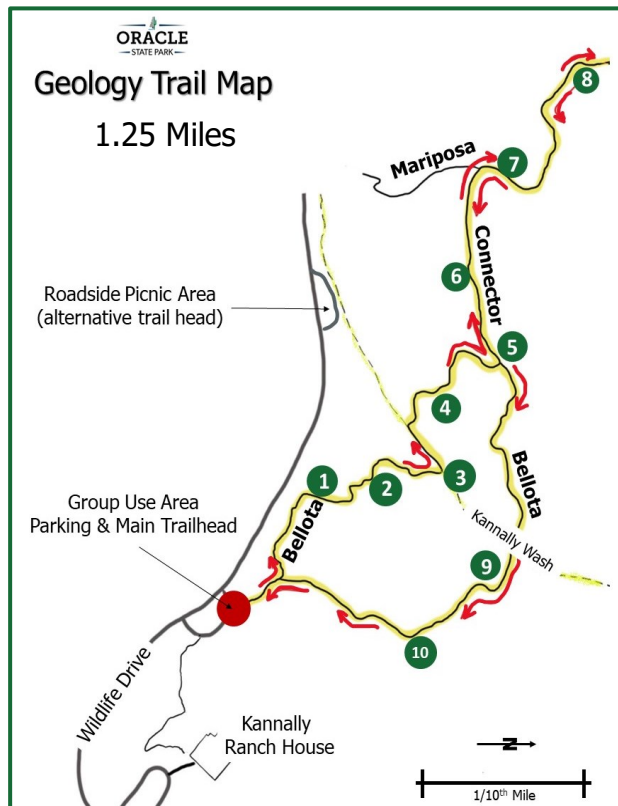


GEOLOGY TRAIL

Self-Guided Tour

The Oracle State Park Self-Guided Tour begins at the Group Use Area Trailhead. Follow the Geology Trail signs to each of the numbered markers (#1 - #10).

Alternatively, you can start the Tour at the Roadside Picnic Area where you follow the wash and begin with marker #4.



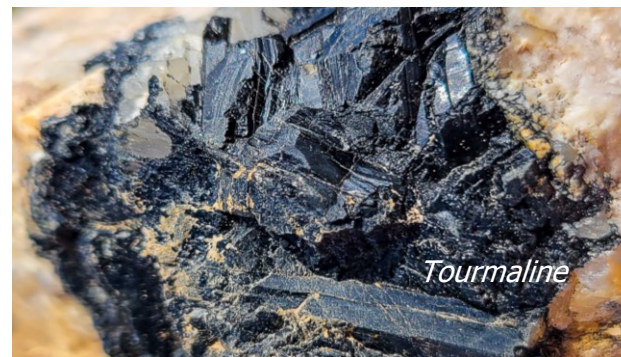
Proceed 0.1 mile to marker #1

Marker #1



The bedrock here is **Oracle Granite**. It formed from molten rock that flowed and crystallized miles beneath the surface 1.4 billion years ago.

After it solidified, magma of a different composition continued to flow upward and intruded Oracle Granite. These intrusions are called **igneous dikes**. Being more erosion-resistant than Oracle Granite, a dike such as this one remains elevated as a ridge.



This dike was accompanied by hydrothermal solutions rich in Boron.

As these hot solutions filled rock openings, black **tourmaline** minerals grew. Tourmaline, at gem quality, can exhibit various colors and is worth more than \$1000 per karat.

Proceed 400' to marker #2

Marker #2



Notice what appears to be blue-green moss on the rocks. Although they look like plants, they are not. They are called **lichens**.

Lichens are a composite organism that results from a

partnership between fungus and algae. The algae provides food, while the fungus offers shade and shelter.



Lichens are found in diverse areas, from Arizona deserts to Alaskan forests. They have long life spans of 100+ years. Their color is determined by the underlying algae.

Lichens have a role in geology. They physically break down rocks by expanding as they hydrate. They also chemically weather rocks by excreting oxalic acid, that bleaches and weakens minerals.

Proceed 300' to marker #3

Marker #3

The third marker is in the Kannally Wash. This dry stream bed originates southwest of the Park and continues northeast for several miles, merging with other washes at the San Pedro Valley.



Washes like this one fill with flowing water and debris during seasonal storms. Notice the black streaks running through the sandy bed. These are created by heavier, iron-rich, magnetic minerals that settle as storm waters flow. The mineral is called **magnetite**. It is one of the two most important iron ores used in steel production.



Storm waters erode the hillsides and expose buried rocks. 1 mile north, this wash cut steep banks revealing the 20 million year old sedimentary rock, **Kannally Conglomerate**. It formed from streams carrying debris as the Catalina Mountains first rose and eroded. It contains rock fragments that span much of our 1.7 billion year geologic history.

Proceed 500' to marker #4

Marker #4



Oracle Granite Outcrop

Marker 4 provides you an opportunity to examine the bedrock of Southern Arizona, called Oracle Granite.

Oracle Granite is the most common rock found at the Park. It is igneous, coarse-grained, with minerals clearly visible to the naked eye. Faulting and extensive erosion, have exposed the bedrock surface, leaving 100s of isolated boulder piles like this one, scattered throughout the southern half of the Park. There are 3 common minerals of Oracle Granite:



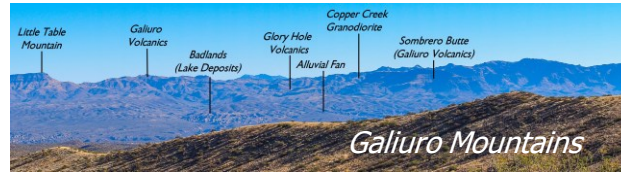
Feldspar: pink color, weathers to a clay that is used in bricks and ceramics

Mica-Biotite: silver-black color, used in cosmetics and auto paint providing sparkle

Quartz – colorless, used in glass

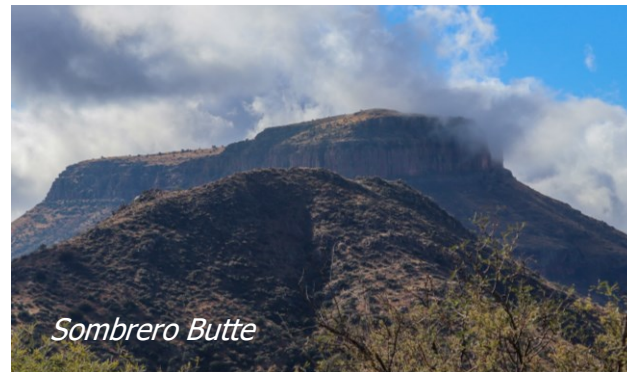
Proceed 300' to marker #5

Marker #5



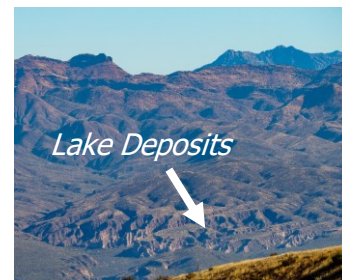
Marker 5, is located at a high elevation on the trail at a shade structure. It offers you views of the Galiuro Mountain Range along the eastern horizon.

The most noticeable feature of the Galiuros are the steep cliffs along the crest and flanks. They were created from eruptions, 70 million and 25 million years ago.



Sombrero Butte

The eruptions were explosive, moving 1,000° F mixtures of rock, ash, and gas 100s of miles per hour down the slopes of volcanic domes. The rock created is a cliff-builder called **ash flow tuff**.



Lake Deposits

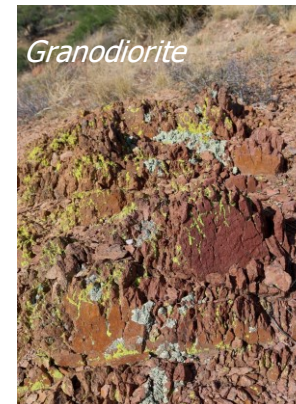
Look for the light-colored cliffs near the base of the range. These cliffs are not volcanic, but rather are the 5 million year old

remains of a lake once located here.

The fossilized bones of camel, horse, and mastodon are buried within these lakebed deposits. Eventually the lake evaporated and minerals like gypsum formed. Gypsum is mined and used in the production of cement and drywall.

Proceed 300' to marker #6

Marker #6



Granodiorite

Geology Trail Marker 6, is located on the left side of the trail that connects Bellota to Mariposa. When you walk on to this pink-gray rock outcrop, notice how it is oriented west to east.

It is an igneous intrusion, or dike, that crystallized along a trend that extends several miles across the Park.

The rock is a **Granodiorite Porphyry** that intruded Oracle Granite about 65-70 million years ago. The magma that produced it was accompanied by hydrothermal solutions that deposited valuable minerals like copper, gold, silver, and molybdenum throughout this area.

Just to the north of the Park, copper mineralization was economically concentrated.



San Manuel Mine

By the 1980s, the San Manuel-Kalamazoo Mine, was recognized as one of the world's largest copper mining operations.

Copper was mainly extracted by an underground operation with shafts up to 4,000' deep. Shallow copper ore deposits were extracted via an open pit method.

The mine was open for over 45 years. Over its life, it is estimated that nearly \$8 billion of copper was produced.



Copper Mine

In the Catalina Mountains to the south, copper formed in a similar manner (via precipitation from hydrothermal fluids). But the host rock in the Catalinas

that received the copper, was often limestone that lay adjacent to the intruding granodiorite porphyry.

In the Galiuro Mountains to the east, lies the Copper Creek Mining District. Copper has been mined in that area since the early 1900s. Geologically, the host rock for copper has a unique history in the Galiuros.

When the granodiorite magma advanced vertically through the overlying rock, it would sometimes subsequently retreat.



Copper Creek Breccia

The retreat left a vacant cavity. The cavity filled with rock fragments from the roof and sides as they collapsed. Hydrothermal solutions then entered and cemented the fragments while depositing copper.

The copper-filled rock is called a **Breccia Pipe**. 100s of these 'pipes' have been discovered, and many have been mined.

Proceed 600' to marker #7

Marker #7



Bedrock Surface

Geology Trail Marker 7 is located on the Mariposa section of the Geology Trail at a cluster of Oracle Granite boulders.



Xenoliths

Scattered throughout the granite surface are 1-5" dark rock fragments. They are not Oracle Granite. When molten rock was flowing upward, it broke through other rocks and typically melted them. Occasionally, the intruded rock did not melt and instead broke off and joined the flowing magma. These foreign fragments are called **xenoliths**. They provide us a rare look at rocks from the earth's deep crust and mantle.

Pinal Schist, is the oldest rock of this area. It was created at the ocean floor. At the Park, it is found as a xenolith.



Alluvial Fans

Notice the rounded hills dominating the Park's north side. The rounded hills, called **alluvial fans**, formed as the Catalina Mountains eroded. Eroded fragments were carried by debris flows and streams and deposited on these alluvial hills that extend to the San Pedro Valley.

Amongst the fragments are limestones deposited in shallow seas that covered this land 300 million years ago.

Escabrosa Limestone



Apache Group Sandy-Limestones

Additionally, the alluvial hills contain rocks created more than a billion years ago when this area was at the shoreline of a continent.

Proceed 700' to marker #8

Marker #8



Inselberg

At Marker 8, you are at the trail's highest elevation. Here, you can observe from a distance or follow the narrow path leading up into this geologic feature.

This group of Oracle Granite boulders is not random, and the rocks did not roll here. The feature is an **inselberg**. It initially formed deep in the earth as part of the Oracle Granite mass. As faults lifted it towards the surface and the overlying rock eroded, cracks formed. Over millions of years the cracks widened as groundwater percolated downward. Once fully exposed at the surface, rainwater, ice, and plant life continued to widen the gaps.

Features you will discover in the inselberg include the following:

Once a granite reaches the surface, pressure is released, and the rock expands. As it expands, external layers delaminate. This is called **exfoliation**.



Exfoliation



Desert Varnish

Notice the dark stains on the Oracle Granite surface. It is called **desert varnish**. It is due to iron and manganese oxides released from inside the rock. It takes 1000s of years for it to form.



Phenocrysts

As you follow the path through the inselberg, you may see oversized, pink-white minerals in Oracle Granite. They are called **phenocrysts**,

comprised of feldspar. These crystals grew faster than the surrounding minerals.

The presence of phenocrysts usually indicates that the magma remained hot for a period, followed by a sudden cooling phase that prevented other minerals from continuing their growth.



Exposed Vein

Partially hidden in the inselberg is an exposed quartz-feldspar vein. This is the result of magmatic fluids, rich in minerals, that entered a gap in the granite.

Reverse direction, retrace steps and Follow signs for 1/2 mile to marker #9

Marker #9



Diabase Outcrop

At Marker 9, you are standing on a 1 billion year old rock called **diabase**. This rock is part of an igneous dike running northward through the Park.

1 billion years ago, the earth's crust was thin

from millions of years of extension. A rift formed, and an iron-rich magma flowed into the overlying rocks. The photo here shows a quartzite rock of the Apache Group intruded by diabase that worked its way as molten rock between the bedding.



Diabase Intrusions

Diabase has several unique properties. It is typically black or dark brown, extremely durable, with a salt and pepper appearance. The most recognizable characteristic is that it is magnetic.

Its durability has been realized throughout history. About 5,000 years ago, masons used diabase as the building material for the pillars at Stonehenge!



Diabase

Unlike granite, diabase has very little quartz. The primary minerals of diabase include clinopyroxene (augite), plagioclase, and magnetite.

Proceed 400' to marker #10

Marker #10



Silty Clay Soil

Marker 10 is a place to examine soil. The grey-black soil at this marker is the result of diabase weathering.

Since diabase has little quartz, the

Soil produced is a very fine silty clay. Some plants have adapted to this soil. But many find it too fertile carrying too much retained water.

Diabase-born soil is relatively scarce at the Park. The most common soil you will find here is called **Grus**. It is derived from the weathering of Oracle Granite. Grus soils are typically well drained, but can also contain clay from the decomposition of feldspar. Native plants are well adapted for Grus soil.



Grus

This is the last stop along the Self-Guided Geology Trail Tour. If you wish to experience more of the geology of this area, please visit the Park's rock and mineral collection on display in the Ranch House. Also, please inquire about the scheduled guided geology tours offered.

We hope to see you again! Thank you.