Badger Springs Trail is in Agua Fria National Monument. From I-17, go east at Badger Springs Exit. Badger Springs Road is the dirt road to the right of the kiosk. Drive 0.8 miles to the large dirt parking lot for the trail.

Joes Hill is a shield volcano 3.5 miles south of Badger Springs Trail. Shield volcanoes are formed by lava flows rather than explosive eruptions and so have gentle slopes because basalt lava has low viscosity and easily flows downhill. This also allows the lava to travel long distances.

Gold is frequently associated with volcanoes. Noble metals, like gold, are transported by magma from deep within the mantle of the Earth to the shallow crust where they form deposits. Hydrothermal fluids (hot water full of dissolved minerals) containing gold also flow up fractures. Gold is deposited when the liquid cools too much to retain the gold in solution. These deposits in fractures are called veins. Richinbar Mine is near the base of Joes Hill about 2 miles southwest of Badger Springs Trail. The main shaft goes 500 feet deep down to a vein of gold-bearing rock. Between the 1890s and 1930s, the mine extracted and processed gold ore.

Joes Hill in background with Richinbar Mine in foreground.

Enjoy the results of the geologic process as you wander down the trail. Be sure to examine the exposed rock at each Stop.

Stop 1: [34.23062N 112.09998W] Badger Springs Trail begins at the sign in stand by the

Stop 1 Red and Yellow Granodiorite

parking lot. From there, hike 200 feet to the first bend in the trail. Look for a large boulder on the right side. A red and yellow granodiorite outcrop is about 50 feet from the right side of the trail. Granodiorite is an igneous rock formed by the cooling of molten material deep underground. The red and yellow colors are created when iron-bearing minerals in the rock are oxidized. The rough white patches are mineral deposits of gravel, sand, and nitrates called caliche.

Dark grey granodiorite rocks are in the wash on the other side of the outcrop. This is the same kind of rock, but it's dark in color because the iron is not oxidized.

Stop 2: [34.23052N 112.09965W] Go back to the trail and continue about 300 feet to just before the gate. A wash angles back from the right side of the trail. The mud in the wash can get deep. Stay clear of the mud and walk up the wash about 150 feet to a 1 foot high ledge of greenish colored granodiorite. The greenish color is caused by chlorite, a mineral formed typically during the early stages of metamorphism, a process where additional heat and pressure can change one kind of rock into another. The red color is caused by oxidized iron.

Stop 2 Greenish colored Granodiorite

Return to the trail. A number of boulders were mechanically moved to the area in front of the gate. On the left side of the trail, one of the boulders has a deposit of

Boulder with Carbonate Deposit

white, black, and red carbonate on top that likely had been deposited in a vein.

Stop 3: [34.22838N 112.09868W] Return to the trail and pass through the gate. The large outcrop shown in the photo is on the right about 1/8 mile down the trail from the gate. Go over to the outcrop and look

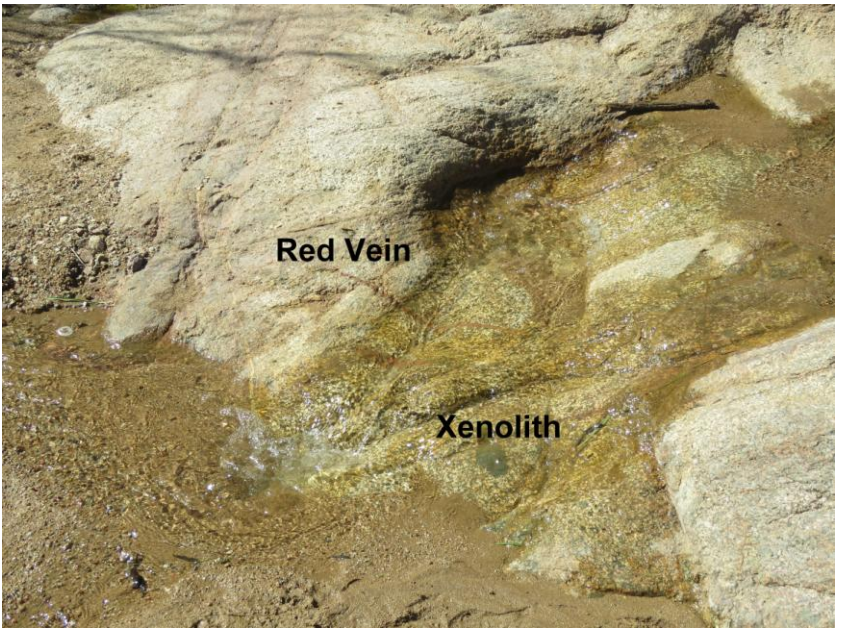
Stop 3 Veins at base of outcrop

at the flat base in front of it. The white and black ribbons in the granodiorite are veins. Granodiorite fractures easily. Hydrothermal fluids filled the cracks and deposited carbonate. Impurities in the carbonate caused different colors. These veins are vertically oriented.

Stop 4: [34.22633N 112.09653W] This stop is about 1/5 mile (1000 feet) from Stop 3. The trail has been on the left side of the wash since the trailhead. A little past Stop 3, the trail enters the wash and then resumes on the right side of the wash. This part of the trail may be flooded. After the trail drops back into the wash, look on the right for the large outcrop in the photo. Red, white, and black veins are in the wash in front of the outcrop. They may be under water. Xenoliths are foreign rocks incorporated into granodiorite as it solidified. They are scattered in the granodiorite around the veins. The hike is now mainly in the wash until Stop 8.

Stop 4 Outcrop

Stop 4 Wash in front of outcrop



Stop 4 Red Vein and Xenolith in wash in front of outcrop

Stop 5: [34.22580N 112.09593W] Continue about 250 feet and look for large smooth boulders. Water flows from a spring about 3 miles to

Stop 5 Smoothed Basalt Boulders

the north. It goes down Badger Springs Wash and empties into the Agua Fria River at the end of this trail. You may have noticed downed trees and branches that came with heavy flows. Weather and water action smoothed the surface of the basalt boulders. Look for white quartz boulders going up the slope on the left side. Depending on the season, they may be covered by vegetation. These probably came from a quartz vein.

The top layer of the mesa is basalt that flowed from the shield volcano around 10.8 million years ago. The bottom layer is granodiorite from the Precambrian Age, around 1.72 to 1.74 billion years ago. The mesa top is 400 feet above you. Over time, water flowing from Badger

Stop 5 Basalt/Granodiorite Boundary near top of photo.
Outlined Quartz Boulders going up mesa in center of photo.

Springs cut through the basalt and granodiorite to form the canyon you see today.

Stop 6: [34.22540N 112.09567W] 150 feet down the trail is a smooth granodiorite outcrop going up the left side. It was smoothed by weather and water action. A large pink and white quartz vein is on the top part way up the outcrop. There are also xenoliths.

Stop 6 Quartz Vein on top

If you didn't see the quartz boulders from Stop 5, look back and you may be able to see them from here.

Stop 7: [34.22448N 112.09538W] About 300 feet further on the trail, look on the left for the large outcrop in the photo. Dark grey to black basalt boulders are on top of and around a brown granodiorite outcrop. The basalt boulders rolled down from the top of the mesa. On the ground in front of the outcrop is a basalt boulder with lots of


Stop 7 Granodiorite Outcrop with Basalt Boulders on top and in front

vesicles (small holes). This boulder was near the surface when it formed and escaping gas left these holes as the rock cooled. Basalt with vesicles is called vesicular basalt. Prehistoric people used vesicular basalt to make metates for milling. Grain and seeds were ground in a metate by pushing a mano (handstone) back and forth over it. The coarseness of vesicular basalt made it especially good for grinding corn. Walk around the boulder until you find the side that doesn't have small holes. This side was possibly under more pressure in the basalt flow so that gas bubbles did not form. The gouges and scratches most likely occurred when it rolled down the mesa. Flood debris may also have caused damage.

Stop 8

Stop 8: [34.22303N 112.09357W] Go about 1/8 mile (650 feet) and take the narrow trail going up out of the wash on the left side. Just after you climb out of the wash, you should see a large, dark grey basalt boulder that rolled down from the mesa top. Part of the boulder has broken off, but both sides are still there. On top of the boulder are prehistoric grinding slicks and bedrock metates. Note that part of each metate is on each piece of the broken boulder. It broke after being used by the prehistoric people. The roll down the mesa could have caused a crack that eventually led to the break. Freezes turn water in the rock to ice which takes up more space. Cracks and breaks happen when the ice expands beyond the constraints of the rock. Historic mining activities may also have been responsible for the break.

Stop 9 [34.22305N 112.09333W] Left Side: The trail continues next to the cliff face. Go about 50 feet and look up to the left for images pecked into the granodiorite rock face. These are prehistoric petroglyphs. The pecked elements are lighter in color than the rest of the surface. The darker surface is called desert varnish. Bacterial microorganisms live on most rock surfaces. They take manganese or iron out of the environment, oxidize it, and cement it onto the rock

surface with clay and other particles. When the surface is pecked, the lighter inner part of the rock is exposed. Over time, the exposed inner part of the rock will darken as the bacterial microorganisms oxidize and cement more particles. Please do not disturb this process by touching the petroglyphs.

Stop 9 Left Side Petroglyphs

Stop 9 Right Side: Before continuing on to the rest of the petroglyphs, turn around and look on the right side of the trail. An arrastra is an historic mill for grinding ore. The stacked granodiorite rocks are remnants of arrastras from the late 1800s. Quartz bearing precious metals were mined from veins. The ore was put in a circular rock-lined pit. Heavy stones were attached to horizontal poles fastened to a central pillar. A draft animal walked around the outside dragging the horizontal pole with the heavy stone until the ore was pulverized. Quartz fragments from the pulverized ore are scattered throughout the rocks. Please leave them in place for others to enjoy. The arrastra could have been powered by water. If you look closely, you may be able to see parallel

Stop 9 Right Side Arrastras

grooves in the flat slabs, the result of the repetitive movements of the drag stone as it crushed the ore.

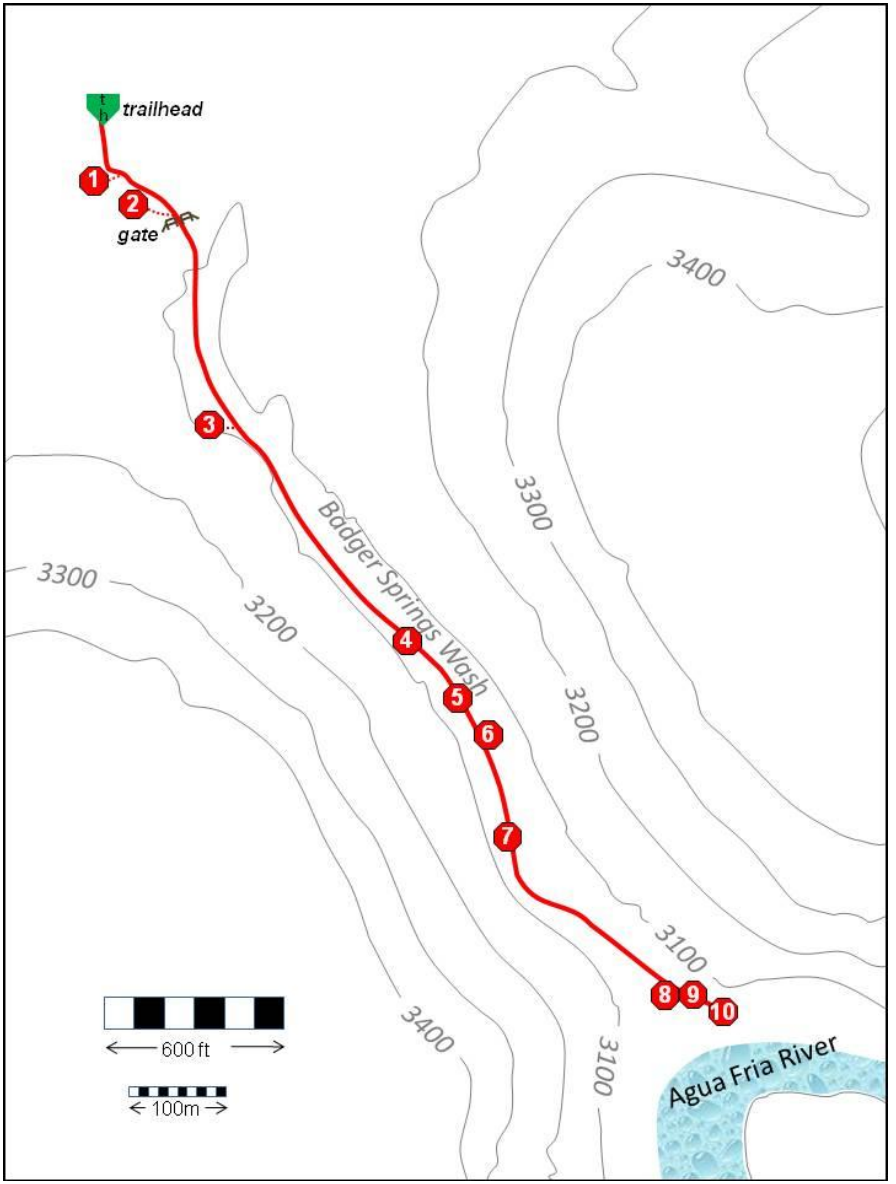
Stop 10: [34.22287N 112.09297W] Scattered petroglyphs are on the cliff to your left as you walk the last 100 feet down to the Agua Fria River. Turn away from the river and look for green splotches and veins on the granodiorite. This is epidote. Epidote typically replaces mineral grains that have been altered by low grade metamorphism.

Turn back and face the Agua Fria River. Water smoothed granodiorite boulders rise up from the water. This is a great place to rest before heading back.

Stop 10 Epidote

These are only a few of the geological features along the trail. Be sure to look for more on your way back.


Stop 10 Agua Fria River



The map is to scale. The red line is the Badger Springs Trail. Each Stop is marked. Dots go to Stops 1, 2, and 3 that are slightly off the trail. The trail is roughly 0.8 miles each way. It is fairly flat and may have stream crossings depending on recent weather. GPS Coordinates are in square brackets for each stop.

Special Thanks to R. Kern, R. Heisler, JJ and Mike Golio, Kim and Wayne Baines, and C. Stone.