

## ***The Big Picture— The Basin and Range province.***

The Little Dragoon Mountains (where Texas Canyon is located) and surrounding ranges, separated by valleys, form part of what physiographers describe as the *Basin and Range province*. In breadth this physiographic province stretches from California and Nevada eastward to west Texas, and in length from Idaho and Oregon southward to central Mexico. Altogether, it encompasses an area of more than 1.8 million square kilometers (695,000 square miles) of western North America. The topography in this area mirrors the stretching and thinning that the earth's crust has undergone over the last 30 million years. In the cooler and more brittle upper crust, stretching is accommodated by faults along which blocks of crust are vertically and horizontally displaced. Blocks of crust that subsided



relative to adjacent blocks underlie the modern valleys. Stretching of the crust in parts of the Basin and Range province continues today, and is particularly active in this part of Arizona. Movement of crustal blocks gives rise to earthquakes. Al-

though infrequent on a human scale, southern Arizona and adjacent areas are prone to large earthquakes. The latest major earthquake, a magnitude 7.2, occurred in 1887 in the San Bernardino Valley of Sonora, a mere 100 kilometers (60 miles) south-southeast of Douglas, Arizona. This earthquake and other smaller ones attest to the ongoing geological activity of the Basin and Range province.

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# **GEOLOGY OF AMERIND**



### **WANT TO KNOW MORE? HERE ARE A FEW BOOKS YOU MIGHT ENJOY READING:**

Baldrige, W.S., 2004. *Geology of the American Southwest: Two Billion Years of Plate-Tectonic History*, Cambridge U. Press.

Chronic, H., 1983, *Roadside Geology of Arizona*, Mountain Press Publ. Co., Missoula, Mt.

Nations, D., and Stump, E., 1996, *Geology of Arizona*, Kendall-Hunt, 2nd ed., Dubuque.



***Are you curious about the distinctive and intriguing rock formations at the Amerind? Why do the rocks in this area look so different? What kind of rock is it?***

Geologists call this rock *quartz monzonite*, but it's often simply called *granite*, and this particular body of rock is the Texas Canyon quartz monzonite. Quartz monzonite is an igneous rock, formed from molten rock (*magma*), which crystallized as it cooled slowly **beneath** the earth's surface. In Texas Canyon, the intrusion of the magma did not reach the earth's surface.

***In places you may see a thin sheet of fine-grained, sugary-textured rock intruded into the monzonite.***

This is called *aplite*, an igneous rock very similar to the quartz monzonite and which is probably derived from it.



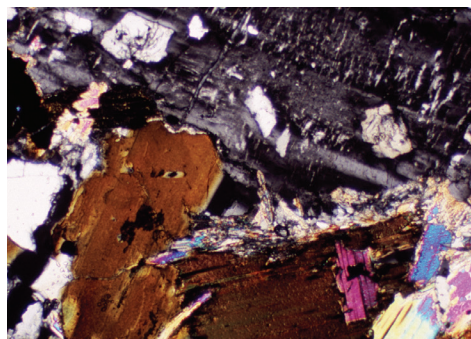
***Look closely and you will see that the rock is made up of several different minerals.***

Most prominent is a potassium-rich feldspar, which forms the large (up to 10 centimeters or 3.9 inches long), blocky crystals, giving the weathered surfaces of the Texas Canyon quartz monzonite a distinctive, rough texture. These large crystals, called *phenocrysts*, grew slowly in the magma as it rose buoyantly toward the earth's surface. Between the phenocrysts is a groundmass consisting of three minerals: quartz (clear, grayish grains), biotite (shiny black flakes), and a second, sodium-rich feldspar called plagioclase (chalky white grains). Altogether, the potassium feldspar, plagioclase feldspar, and quartz



occur in approximately equal proportions—the definition of quartz monzonite! In addition to these minerals, several others such as muscovite, magnetite, apatite, zircon, and chlorite occur in tiny amounts, visible only with a microscope.

***A photomicrograph allows us an even closer look at the Texas Canyon quartz monzonite.***



*The dark gray, speckled mineral is potassium feldspar; brown is biotite; brightly colored grains are muscovite. White grain on the left is quartz.*

*Width of photo is approx. 2.7 millimeters, or 1/8 inch.*

***These rocks are old, right?***

Actually, the rocks of Texas Canyon are relatively young compared to the age of the earth (4.6 billion years). The intrusion of magma occurred in pulses over a period of time, crystallizing between 50 and 55 million years ago. The last dinosaurs were extinct 10 million years before these rocks were formed. The age of an igneous rock can be determined by a variety of methods, generally using the decay of naturally occurring radioactive elements incorporated into the crystal structure of the minerals.

***These spectacular balanced boulders, part of the dramatic landscape at Amerind, are formed by natural weathering processes.***



Natural weathering of the rock creates the distinctive pedestals and balanced boulders that characterize the Texas Canyon quartz monzonite. Weathering occurs at exposed surfaces and along joints (planar fractures or cracks) that divide the rock into irregular blocks. Tiny cracks that form between the larger crystals allow water and oxygen to invade and weaken the rock, and over millions of years, pry mineral grains apart. The reddish or brownish patina that colors the surfaces derives from the breakdown of iron-bearing minerals. Where joints intersect the ground surface or each other, weathering attacks the rock from two or more directions, rounding the corners and edges of blocks.



*Sheets of quartz monzonite spall off the outer portions of boulders along curved cracks or joints, contributing to their rounding. This process, known as "exfoliation," is aided by freezing and thawing of moisture that infiltrates the cracks. Scale is 12.5 centimeters, or 4.9 inches long.*

The dramatic pedestal rocks, spires, and balanced boulders that characterize the distinctive landscape at Amerind and throughout the outcrop area of the Texas Canyon quartz monzonite achieved their forms as the rock around them disintegrated. As the land surface was slowly lowered by erosion, the more resistant rocks remained high. The surrounding rocks generally weather differently because they are finer-grained and formed in a different geologic environment, thus creating a landscape of different appearance.

***What if the magma intrusion in Texas Canyon had risen to the earth's surface?***

In the nearby Chiricahua Mountains, 64 kilometers (40 miles) east of Amerind, similar magma reached all the way to the earth's surface 26.8 million years ago. The resulting catastrophic eruption created an enormous deposit of lava and ash, and a gigantic collapse crater. Today, the remnants of the widespread ash blanket, which can be seen prominently in Chiricahua National Monument, have been eroded into oddly-shaped and dramatic columns and spires.

