Geology of Lower Ruins Tonto National Monument

Why is This Important?

The Tonto National Monument is known for its well-preserved cliff dwellings that were occupied during the 13th, 14th, and early 15th centuries. But, if it weren't for geologic processes, the shallow caves that shelter the dwellings would never have been formed. The caves started forming between 50,000 to 400,000 years ago when water dissolved the minerals binding the rocks together. The creation of the caves set the stage for where the Salado people would settle and build their dwellings.

The Lower Ruin

The trail to the Lower Ruin starts on the unconsolidated rock debris derived from the bedrock around and above the ruin. As the ruin is approached, more and more of the upper member of the Dripping Spring quartzite formation is exposed where the Gila conglomerate has been stripped away by erosion. At the mouth of the cave, the cemented debris plaster at the bottom of the Gila conglomerate is exposed, and inside the cave are rocks of the upper member of the Dripping Spring quartzite.

Near the mouth of the cave, the rocks of the Dripping Spring quartzite are bleached by near-surface weathering and the color is pale yellow and buff rather than the distinctive dark gray. Toward the back of the cave, the effects of weathering are less, and the rocks are darker in color. These colors can be seen only after the smoke-blackened outer surface has been removed.

The rocks that can be seen as one looks out from the trail to the Lower Ruin include diabase (marked by the distinctive olive-green colored soil) and the upper member of the Dripping Spring quartzite, which is the principal cliff-former in the area. Out crops of Pioneer formation, Barnes conglomerate, and the lower member of the Dripping Spring quartzite are on the flanks of Cholla Canyon to the south. The Mescal limestone is the pale clay rock capping some of the hills, the Gila conglomerate fills Roosevelt basin to the north, and diabase and rocks of the Apache group contribute almost all of the high country seen along the northern horizon.

Origin of the Caves

The caves at Tonto National Monument were formed mostly by natural processes, although the Salado no doubt enlarged the caves by clearing out already loosened rock.

Lower cliff dwelling

Caves form by solution, abrasion, and spalling. All of these processes may contribute to the development of a particular cave but only one process will be dominant in forming that cave; the others will have only a subordinate role. Although all of these processes are extremely slow, there has been ample time available at the Monument. The caves probably started to form at least 50,000 years ago and may be as long as 400,000 years ago.

Spalling is the most common cause of caves in rocks other than limestone. The caves at the Tonto National Monument are examples of caves formed mainly by spalling. Spalling is caused by cracks forming in the rocks and then being enlarged until a piece of rock falls off. The role of water in this process is dominant. It weakens the rock by carrying away binding materials in and adjacent to existing fractures, and it expands upon freezing, which causes existing cracks to be enlarged.

Water also causes some clay minerals to expand, which may form and enlarge cracks. Plant life contributes to spalling by sending root systems into cracks and enlarging them as the roots grow. Solution and abrasion can contribute to spalling because solution can weaken rocks cemented by soluble material and can remove soluble material that fills fractures. Abrasion of wind blown sand grains, wind-buffeted pebbles, and nesting animals can form holes that catch water, which then could freeze or seep into cracks exposed in the hole, leading to spalling.

At the Tonto National Monument, all of the caves occur in the upper member of the Dripping Spring quartzite in a layer of rock 50 to 75 feet thick that is particularly susceptible to spalling. The Dripping Spring quartzite is between layers of

more resistant rock. Without these more resistant layers, the caves probably would not have developed. The more resistant rocks tend to create a ceiling and floor for the caves by limiting the spalling to the favorable unit and by forming cliffs that yield more slowly to erosion (Figure 1). Several characteristics of the easily spalled rocks can be singled out as factors contributing to cave development, such as thin strata, cross-strata, stylolites, joints, and shear zones. All of these weaken the rock, permit easier access of water, and lead to breakage into small pieces.

There is abundant evidence that the rocks in the Lower Ruin cave are weak and that water has had easy access. The bedding planes, numerous joints, and many small shear zones that crisscross the rock weaken it and permit easy breakage. The widespread weathering of the rocks, the effects of which weaken the rocks, and the deposits of calcium carbonate, such as stalactites, indicate that these joints and shear zones have served as channel ways for water. Although in terms of geologic processes, water has had easy access to the caves, but the volume would not have been nearly enough to make the living quarters damp.

Some of the characteristics of the rock that facilitate spalling are uniformly present throughout the rock unit that contains caves, but the fact that caves are not present everywhere in the unit indicates other characteristics of the rock must control the location of the caves. It is very likely that the rocks where caves develop, as at the Lower Ruin, have been more thoroughly broken than rocks where no caves developed, even though the general rock type is the same. Only careful study of structural trends and relative abundance of fractures could substantiate this theory.

This fact sheet is adapted from Robert Raup's 1962 report titled *Some Geological Features of the Tonto National Monument*. It is available through the National Park Service's archives.

For Further Reading

Tonto National Monument Fact Sheets

Geologic History
Geologic Features

Books

Waters, Michael. (1997). *Principles of Geoarchaeology: A North American Perspective*. Tucson, AZ: University of Arizona Press.

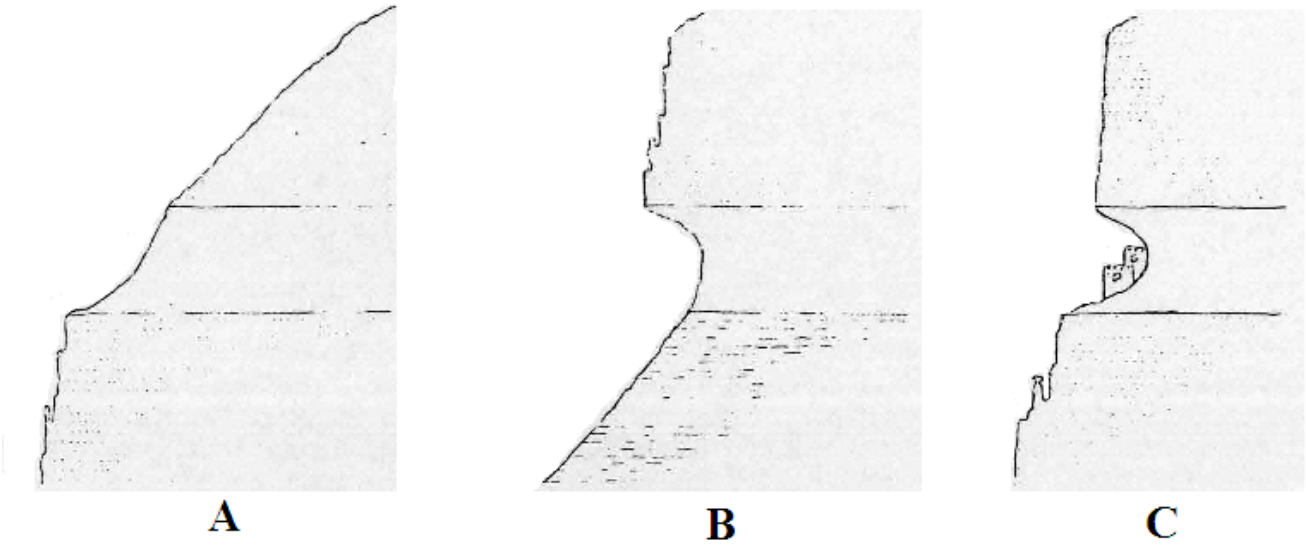

Figure 1
A. Non-resistant rock above and resistant rock below easily spalled rock – no caves form
B. Resistant rock above and non-resistant rock below easily spalled rock – no caves form
C. Resistant rocks above and below easily spalled rock – caves form