Devils Playground, Box Elder County

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Utah Geosites

2019

Utah Geological Association Publication 48

M. Milligan, R.F. Biek, P. Inkenbrandt, and P. Nielsen, editors

Cover Image: *Miniature arch in granitic rock formed due to honeycomb weathering.*

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Utah Geosites showcases some of Utah's spectacular geology, both little-known localities and sites seen by visitors to Utah's many national and state parks and monuments. The geosites reflect the interests of the many volunteers who wrote to share some of their favorite geologic sites. The list is eclectic and far from complete, and we hope that additional geosites will be added in the coming years. The Utah Geological Survey also maintains a list of geosites https://geology.utah.gov/apps/geosights/index.htm.

We thank the many authors for their geosite contributions, Utah Geological Association members who make annual UGA publications possible, and the American Association of Petroleum Geologists—Rocky Mountain Section Foundation for a generous grant for desktop publishing of these geosite papers.

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Presidents Message

I have had the pleasure of working with many different geologists from all around the world. As I have traveled around Utah for work and pleasure, many times I have observed vehicles parked alongside the road with many people climbing around an outcrop or walking up a trail in a canyon. Whether these people are from Utah or from another state or country, they all are quick to mention to me how wonderful our geology is here in Utah.

Utah is at the junction of several different geological provinces. We have the Basin and Range to the west and the Central Utah Hingeline and Thrust Belt down the middle. The Uinta Mountains have outcrops of some of the oldest sedimentary rock in Utah. Utah also has its share of young cinder cones and basaltic lava flows, and ancient laccoliths, stratovolcanoes, and plutonic rocks. The general public comes to Utah to experience our wonderful scenic geology throughout our state and national parks. Driving between our national and state parks is a breathtaking experience.

The "Utah Geosites" has been a great undertaking by many people. I wanted to involve as many people as we could in preparing this guidebook. We have had great response from authors that visit or work here in the state. Several authors have more than one site that they consider unique and want to share with the rest of us. I wanted to make the guidebook usable by geologists wanting to see outcrops and to the informed general public. The articles are well written and the editorial work on this guidebook has been top quality.

I would like to personally thank Mark Milligan, Bob Biek, and Paul Inkenbrandt for their editorial work on this guidebook. This guidebook could not have happened without their support. I would like to thank Jenny Erickson for doing the great desktop publishing and the many authors and reviewers that helped prepare the articles. Your work has been outstanding and will certainly showcase the many great places and geology of Utah. Last, but not least, Thank you to the American Association of Petroleum Geologists, Rocky Mountain Section Foundation for their financial support for this publication.

Guidebook 48 will hopefully be a dynamic document with the potential to add additional "geosites" in the future. I hope more authors will volunteer articles on their favorite sites. I would like to fill the map with locations so that a person or family looking at the map or articles will see a great location to read about and visit. Enjoy Guidebook 48 and enjoy the geology of Utah.

Peter J. Nielsen
2019 UGA President

INTRODUCTION

Why take your kids to the neighborhood playground, when you can visit a playground that inspires their sense of geologic adventure? Devils Playground is not your ordinary community playground, but a wonderland of granitic rock weathered into fantastic forms and weird shapes (figure 1). Occupying an assortment of Bureau of Land Management, state, and private land in the Bovine Mountains, Devils Playground is a relatively unknown geologic curiosity found in a remote corner of northwestern Utah.

Devils Playground is situated in the physiographic region known as the Great Basin province that extends across western Utah, Nevada, and to the Sierra Nevada Mountains in eastern California. The area is composed mostly of granitic rocks of the Emigrant Pass intrusion. A combination of granitic rock, faulting, and weathering under a semiarid climate created favorable conditions for the creation of Devils Playground. Desert plants such as sagebrush, Utah juniper, pinyon pine, Mormon tea, and cheatgrass are common throughout the area.

Figure 1. *View of one of the many granitic rock exposures in Devils Playground.*

GEOLOGIC HISTORY

The rocks of Devils Playground formed approximately 41 to 34 million years ago from an intrusion of magma into overlying Paleozoic (300 to 240 million years old) sedimentary rocks. Known as the Emigrant Pass pluton, this intrusion occurred in three stages and is one of at least three distinct intrusive centers in northwestern Utah. The pluton is estimated to have been emplaced at depths less than 6 miles (10 km) into the country rock (Egger and others, 2003).

Beginning approximately 13 million years ago, extensional forces thinned and fractured the Earth's crust within the Great Basin, creating a vast network of north-south trending faults. Along these faults, mountains were uplifted and valleys were down-dropped producing the distinctive landscape of the Great Basin. These geological processes are still operating today throughout the Great Basin region.

One of these north-south trending faults, the Grouse Creek Mountains fault, led to the uplift of Grouse Creek and Bovine Mountains where Devils Playground is found. Following uplift, the bedrock was subjected to weathering and erosion by water, ice, wind, and other agents. Over millions of years, these erosional processes slowly peeled off the overlying sediments and sedimentary rocks. Erosion removed roughly 3 to 6 miles (5-10 km) of rock and sediment before exposing the granitic rocks of the Emigrant Pass pluton.

Between 28,000 and 12,000 years ago, a lake called Lake Bonneville covered much of the area directly south of Devils Playground. Lake Bonneville was the largest late Pleistocene lake in the Great Basin (see, for example, Oviatt and Jewell, 2016) (figure 2). Around 14,500 years ago, the lake overflowed at Red Rock Pass in Idaho, initiating a massive flood that made its way to the Snake River. The lake fell approximately 328 feet (100 m) and at its maximum discharge, the flood released an estimated 35 million cubic feet per second (cfs) of water (1 million cubic meters per second) (Janecke and Oaks, 2011). Sediments and shorelines of Lake Bonneville can be found southeast of Devils Playground.

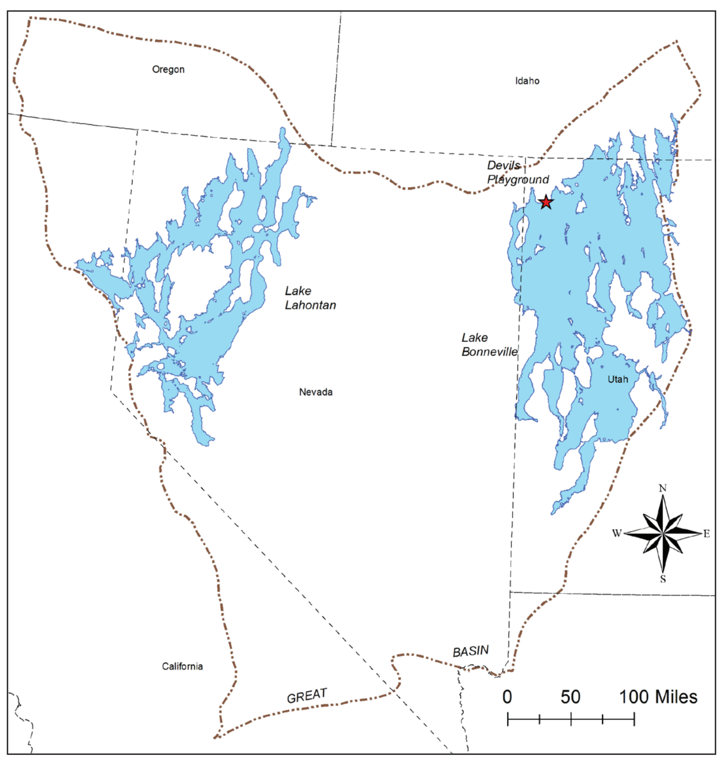

Figure 2. *Location of Lake Bonneville in the Great Basin. Lake Bonneville is shown at its highest level (modified from Oviatt, 1997). Red star indicates the location of Devils Playground. Digital compilation by Carmen McDonald.*

STRATIGRAPHY

The rocks of the Devils Playground area consist of granitic rock intruded into late Paleozoic interbedded sandstones and limestones; these sedimentary rocks are locally metamorphosed. Additionally, surficial deposits derived from the local bedrock are found throughout the area. Geologic units are shown on the stratigraphic column in figure 3 and the geologic map on figure 4.

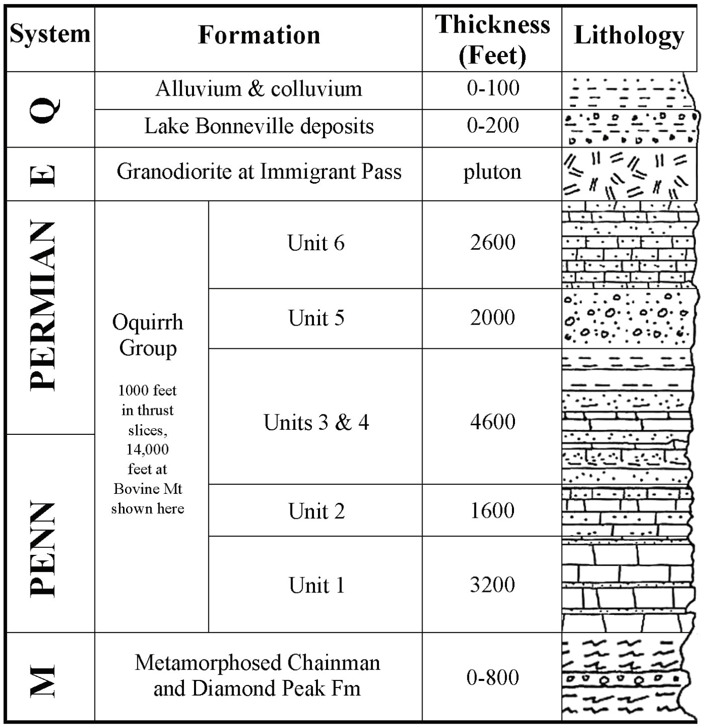

Figure 3. Stratigraphic column showing formations exposed in the Devils Playground area, including thickness and lithology (modified from Hintze and Kowallis, 2009). Digital compilation by Carmen McDonald.

Mississippian Rocks

Diamond Peak Formation and Chainman Shale (IPMdc)

This bedrock is the oldest exposed in the area and consists of metamorphic rock such as dark-gray to black phyllite, fine-grained semischist, gray sandstone, and gray pebble conglomerate and marble (Miller and others, 2019). The bedrock mostly crops out in the Grouse Creek Mountains (northwest of Devils Playground), however two small outcrops are just northeast of the turnoff from State Highway 30.

Permian Rocks

Oquirrh Group (Poi)

The Oquirrh Group consists of interbedded sandstone and limestone deposited in a marine environment (Hintze and Kowallis, 2009). This bedrock has been altered in areas by intrusion of the Emigrant Pass pluton (Tepg). This alteration process is called contact metamorphism because a hot magma body comes in contact with country rock, altering its mineral composition and texture. Good examples of this alteration can be found south and west of Devils Playground.

Eocene Rocks

Emigrant Pass pluton (Tepg)

The Emigrant Pass pluton crops out in three lobes and covers an area of approximately 10 square miles (25 km^2) in the southern part of the Grouse Creek Mountains (Doelling, 1980; Miller and others, 2012, 2019 in review). The rock is mostly granite containing equal parts of quartz, plagioclase, potassium feldspar, and biotite (Miller and others, 2012). Other intrusive rocks found in the area include granodiorite, quartz diorite, diorite, and monzonite. Also found throughout the granitic rock are pegmatites (coarse-grained igneous rocks with

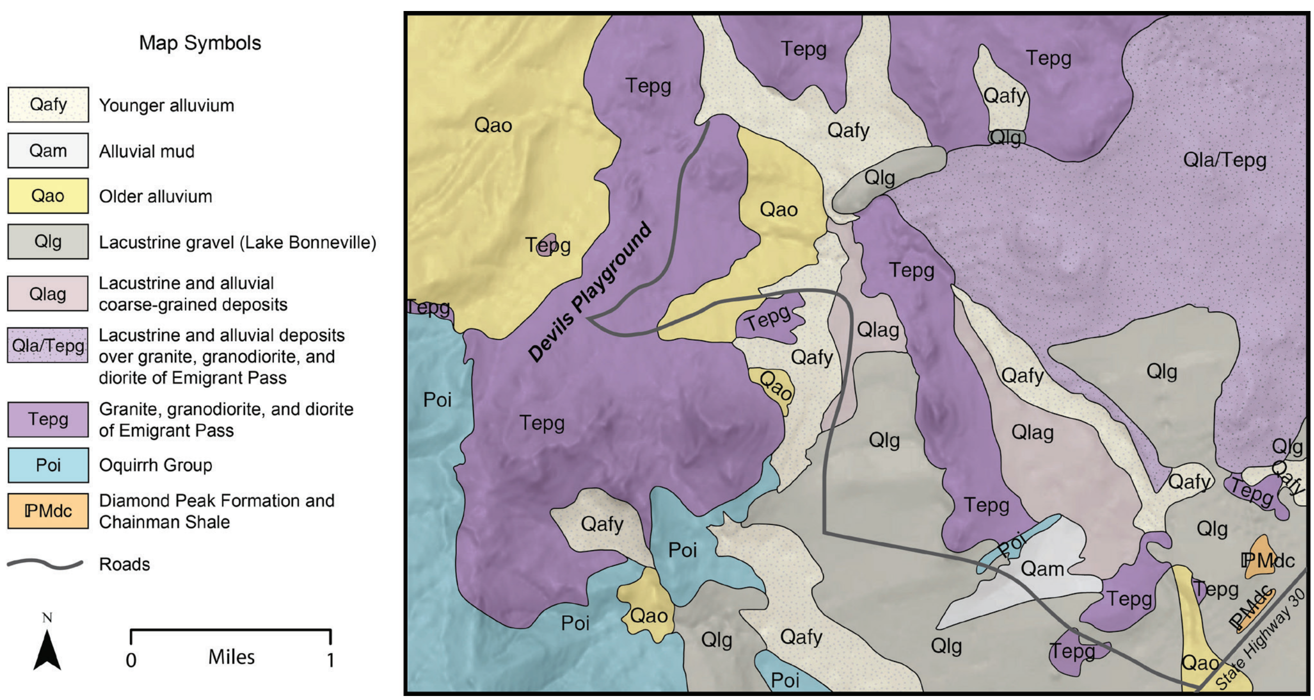

Figure 4. Geologic map of Devils Playground. Geology modified from Miller and others (2012) and Miller and others (2019). Digital compilation by John Good.

interlocking quartz, feldspar, goethite after pyrite, and muscovite). These pegmatites formed during the late stages of the intrusion and are found throughout the pluton, usually as irregular dikes or veins several inches to 3 feet (<1 m) in thickness, and extend hundreds of feet (figure 5). They represent the last and most hydrous (water-rich) portion of magma to crystallize. The pegmatites are easy to locate because they are more resistant than the surrounding rock, thus they resemble ribs and bones sticking out in relief. Some of the pegmatites contain pockets of loose quartz and feldspar crystals in the center portion of the pegmatite veins (figure 6). These crystals formed when the internal pressure of the pocket exceeds the confining pressure of the surrounding rock, thus causing the pockets to rupture in an explosive manner, fracturing many of the crystals and breaking them from the wall rock. After the breakage, mineral growth continues within the pocket forming new terminations on the broken ends of crystals. Some of these quartz crystals are smoky or gray-black in color. This color is due to natural gamma irradiation and the presence of trace amounts of aluminum within the crystal structure.

Quaternary and Holocene Deposits

Older Alluvial Fans (Qao)

Older, pre-Bonneville alluvial fans are present mostly north and west of the Devils Playground area. The alluvial fans are deeply eroded and comprised of poorly sorted sand, mud, and boulders deposited by debris flows and derived from erosion of local bedrock.

Figure 5. Pegmatite vein in granitic rock. Notice exposed pocket. Keys for scale.

Figure 6. Smoky quartz and feldspar specimen found in a pegmatite at Devils Playground.

Lacustrine gravel, Lake Bonneville (Qlg)

Upper Pleistocene Lake Bonneville gravel and sand is present along the access road east of Devils Playground. The high stand of Lake Bonneville, preserved as the Lake Bonneville shoreline, forms an arcuate, berm-like barrier across Sand Wash.

Lacustrine and alluvial coarse-grained deposits (Qlag)

Holocene to upper Pleistocene sediment found mostly southeast of Devils Playground. These sediments consist of mixed layers of coarse-grained Lake Bonneville sediments and younger alluvial sand and gravel.

Lacustrine and alluvial deposits, undivided over Tertiary bedrock unit (Qla/Tepg)

Holocene to upper Pleistocene Lake Bonneville gravel and sand that mostly cover Emigrant Pass intrusive rocks (Tepg). This unit is quite extensive and found mainly east of Devils Playground.

Alluvial Mud (Qam)

Holocene mud and sandy mud that accumulated behind Lake Bonneville gravel barriers.

Younger Alluvial Fans (Qafy)

These younger Holocene alluvial fan deposits consist of mud, sand, and gravel found in washes and valley bottoms. These sediments are often deposited in high-energy flash flood events from summer thunderstorms and are therefore poorly sorted.

GEOLOGIC UNIQUENESS

"Devils," alcoves, spires, arches, small caves, bowls, and honeycomb patterns can be found throughout the area and offer an explorer endless opportunities of discovery. These extraordinary forms of the granitic rock owe their structure to a variety of physical and chemical weathering processes. These processes began sculpting the rocks immediately after they were exposed by erosion. The two most conspicuous processes at Devils Playground are spheroidal (onion-skin) and honeycomb weathering.

Spheroidal weathering is commonly found in granitic rocks and is showcased at Devils Playground (figure 7). In spheroidal weathering, joints or fractures create initial openings allowing surface water to access the rock from all sides. Water seeping along these fractures slowly decomposes or alters the mineral composition of the granitic rock, causing the rock to weather inward. As a result, rounded shells of decomposing rock are repeatedly loosened and peeled off the unweathered rock core like layers of an onion. The rate of weathering is greatest along the corners and edges where fractures and joints intersect because they have a greater surface-area-to-volume ratio than the rock faces. Eventually, the rock core eventually becomes an isolated rounded boulder at the ground surface and is referred as a corestone or woolsack.

Figure 7. Granitic rock that exhibits spheroidal weathering.

However, some rock at Devils Playground display another type of weathering called honeycomb weathering, also known as alveolar weathering (figures 8 and 9). Here, weathering creates pockets or cavities known as tafoni, giving the rock a honeycomb or stone lattice appearance. This weathering is found throughout the world in semi-arid regions, coastal areas, Arctic deserts, and even on historical buildings (Rodrigues-Navarro and others, 1999). The weathering is likely produced by biological, chemical, and physical factors operating in the micro-environment. Salt weathering is often attributed for the honeycomb features found along the coast or in deserts. Nearby salt from the soil, playas, or the ocean is deposited on the surface of the rock by the wind and rain. The water allows the salt to bind to the rock, so as the salt solution evaporates, the salt begins to crystallize and grow within the pore spaces of the rock. These salt crystals then pry apart the rocks's mineral grains and form pits in the weathered material resembling a honeycombed structure. Other mechanisms that may contribute to the honeycomb pattern may include the wind, freeze-thaw cycles, humidity, bedding, and solar radiation (Davis, 2012). In the case of Devils Playground, several of these mechanisms likely contributed to the formation of the honeycomb appearance of the rocks we see today.

Eventually, these weathering processes will destroy all of these current artistic forms of nature. However, these processes will continue to sculpt new features as long as weathering and erosion continues to uncover granitic rock at Devils Playground.

***Figure 8.** Honeycomb weathering found at Devils Playground. Sunglasses for scale.*

***Figure 9.** Miniature arch in granitic rock formed due to honeycomb weathering.*

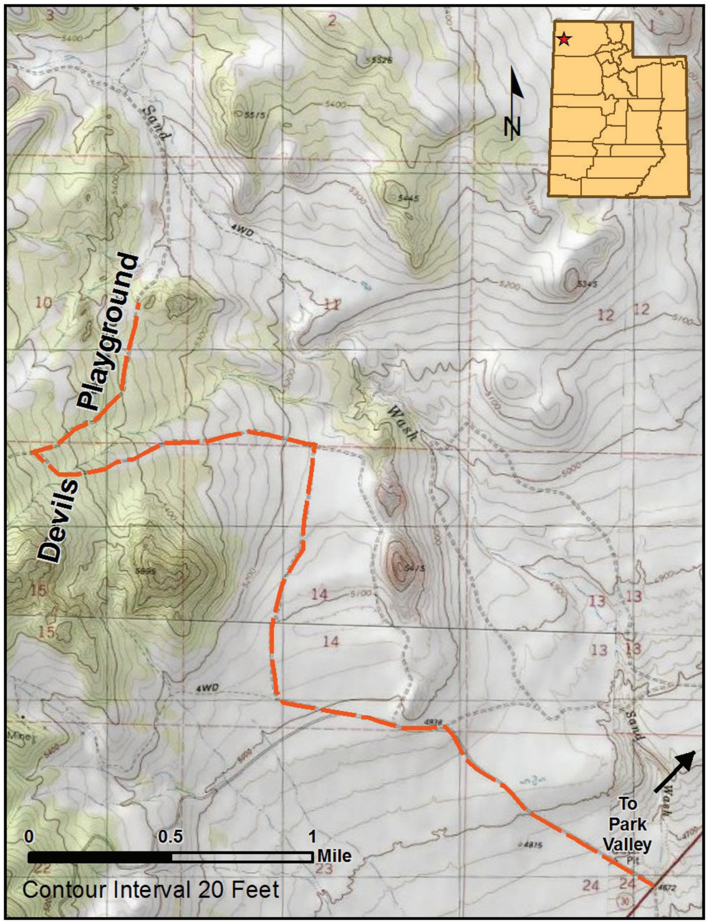

Figure 10. Location map of Devils Playground. Digital compilation by Adam Clark.

SUGGESTED DRIVING INSTRUCTIONS

From the northern I-15/I-80 interchange in Salt Lake City, travel north on I-15 for 69 miles (111 km) to Tremonton (exit 379). At exit 379, the freeway splits; I-84 continues to the northwest (left), and I-15 branches off and goes north (right). Travel northwest on I-84 for 37 miles (60 km) to exit 5. Turn left (west) on State Highway 30 and travel 16 miles (28 km) to Curlew Junction (a junction with State Highway 42). Turn left (southwest) and proceed 49 miles (79 km) to the Devils Playground Road. There is no sign at this turnoff, however there is a bright yellow cattle guard that marks the entrance into Devils Playground. Turn right (north) and drive approximately 1 mile (1.6 km) to the first granitic outcrops on the right (northeast) side of the road. If you proceed on this road for several miles, the road will end up in the heart of Devils Playground. The UTM coordinates (WGS84) of Devils Playground are: Zone 12T E: 277958 N: 4599061.

ACKNOWLEDGMENTS

I thank the many people who provided assistance on this paper, in particular Joel Williams Utah Division of Water Resources (DWRe) who authorized the time in the busy work week to complete the manuscript. Jim Davis and Greg McDonald Utah Geological Survey (UGS) reviewed the manuscript and provided additional information to the text. Also, special thanks to the Adam Clark and Carmen McDonald (DWRe) who helped with the digital compilation of the location map and stratigraphic column for the text. Also, thanks to Don Clark (UGS) for use of unpublished geologic mapping and John Good (UGS) for the digital compilation of the geologic map.

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