

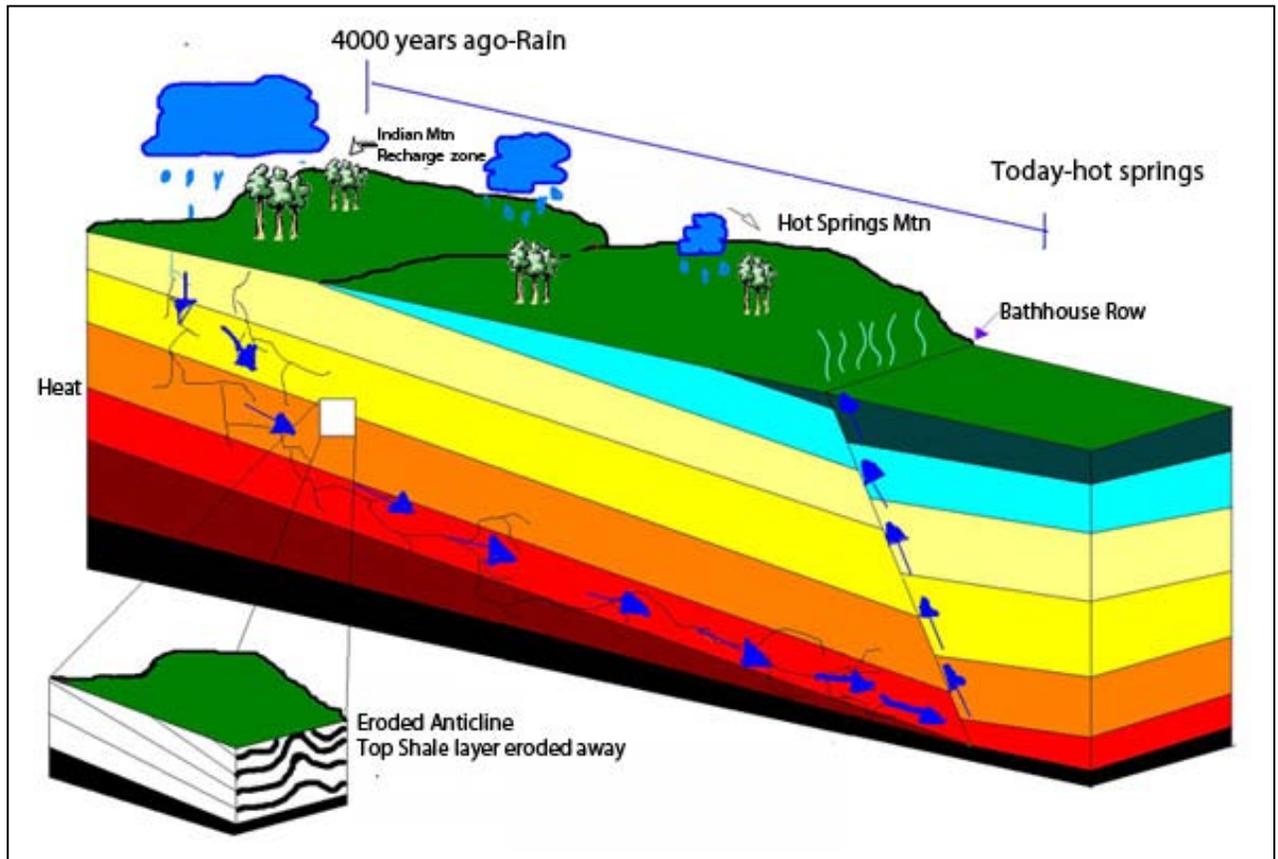
Hot Springs

National Park
U.S. Department of the Interior



Hot Springs National Park
Arkansas

In Hot Water – Excerpts from *Fire in Folded Rocks* by Jeffrey Hanor



The Origin of the Springs

The origin of the hot springs has been debated since the time of Dunbar and Hunter's visit in 1804. Most explanations have focused on one of two alternatives: Do the waters rise from hot magmas at depth? Or are they originally rainwater which has percolated down deep into the earth's crust, there to be heated by some unknown process? Over the last several decades, sensitive chemical techniques have been developed that provide some of the answers to these questions.

The water of the hot springs, like all water, is made up of the elements hydrogen and oxygen in the form, H_2O . Each of these two elements has closely similar forms known as **isotopes**. Geochemists at the

United States Geological Survey have measured with great accuracy the abundance of the isotopes of hydrogen and oxygen in the spring waters. By comparing these results with the results obtained by analyzing large numbers of different kinds of waters from all over the world, these scientists conclude that this water now flowing from the hot springs is **not** water given off by cooling magmas at depth. It is, in fact, **rainwater**. Furthermore, analyses of carbon-14, another isotope present in the water, indicate that this rainwater originally fell in the Hot Springs area some four thousand four hundred years ago.

The Source of Heat

How does four thousand year old rainwater become heated to an average temperature of 143°F (61°C)? The answer is still speculative. We do know that the temperature of the earth's crust increases with depth. The average increase worldwide is on the order of 3-5°F (2-3°C) for every additional 300 feet of depth and is due to the release of heat by the natural radioactive decay of potassium,

uranium and thorium in the crust as well as from compression at great depths of the planet's interior by gravity. We can heat rainwater simply by letting it percolate downward to the desired depth and temperature. If we can then make this heated water rise back up to the surface rapidly, so that it doesn't have a chance to cool, we will make a hot spring.

Evidence in the Park

What are the details of this process in the park area? Best evidence indicates that most of the rain which is transformed into the thermal water is collected in the mountains in the northeastern part of the Garland County. This area is underlain by the Bigfork Chert, a hard, brittle rock that is extensively fractured and broken as a result of mountain-building activity of the past. Water flows readily through the numerous cracks and pores which penetrate this rock, and there are numerous cold-water springs in the valley. Some of the rainwater is probably collected along the ridges of Arkansas Novaculite which flank the valley. The Novaculite is brittle, and some of it is also quite porous. It was similarly fractured during folding and uplifting.

Rainwater falling into this area first percolates down through a shallow and rocky soil cover. Here, it picks up carbon dioxide gas given off by organisms living in the soil. The carbon dioxide dissolves in water, forming carbonic acid. As the rainwater continues to percolate downward through the Bigfork Chert and Arkansas Novaculite, the carbonic acid causes the water to dissolve grains of calcium carbonate and other minerals scattered throughout the rock.

The rainwater is thus gradually transformed into a mildly alkaline, pleasant tasting solution. The journey downward is slow, a little more over a foot (30 centimeters) per year. As the water becomes heated at depth, it also dissolves silica from the surrounding rocks. The amount of silica present in the water provides the geochemists with an accurate indication of the maximum temperature to which the waters are heated.

Waters collected throughout the broad expanse slowly converge at a maximum depth of probably between 6000 to 8000 feet (1800 to 2400 meters) to a point just west of the Bathhouse Row area. Here the rocks are cut by a series of large faults. Cracks and fractures associated with these faults provide the hot water with a ready escape route up to the surface. The trip is so rapid, that there is very little cooling of the water. Of the approximately four thousand years it takes the rainwater to make its round trip, perhaps only a year or so at the very most is needed to get back up to the surface.

At the Surface

As the hot waters approach the surface, there is a small amount of mixing with cooler, surface waters. The presence of small traces of tritium, an isotope of hydrogen produced by natural processes in the upper atmosphere and by aboveground testing of thermonuclear bombs, indicates that some of the spring water is less than 20 years old. This is not surprising because rainwater can readily soak into the porous tufa and underlying soil. The hot waters seep up through a broad fracture zone that strikes northeast across the face of Hot Springs Mountain. Old tufa masses indicate that at one time some of the spring waters discharged higher up on the hillside than they do today.

Within historic times, some of the spring channels have ceased to flow while others have seen a surge of activity. Some of the changes are the results of man's activity. When a well was drilled for the Fordyce Bathhouse, one of the springs, formerly a trickle, leaped to life, while another which flowed vigorously, nearly dried up.

Episodes such as this provide credence to the argument that the springs are interconnected. The upper springs, in fact, are in delicate balance with those at lower levels. Increased flow from the lower springs usually results in decreased flow above.

When rising hot waters in uncovered springs come in contact with the atmosphere, they lose some of the dissolved carbon dioxide they picked up on their trip down. As this gas effervesces out of solution, some of the calcium carbonate that is dissolved at depth precipitates out. The crystals of calcium carbonate are very tiny and give the tufa an earthy appearance. It is interesting to realize that precipitation results from loss of gas, not cooling of the water. Calcium carbonate is one of those odd substances that are actually more stable in cold water than hot. Trace amounts of dissolved iron in the water oxidize, giving some of the tufa an orange or reddish color.

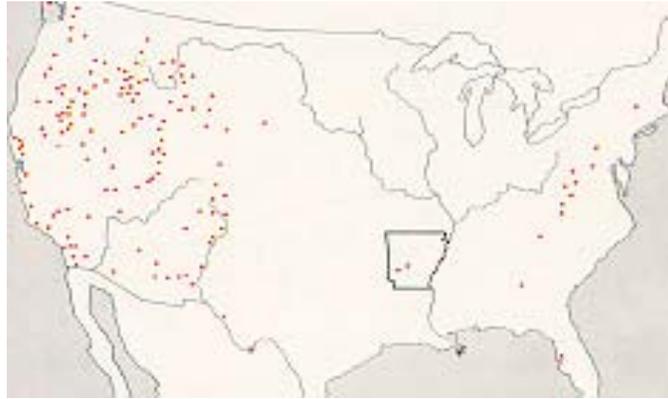
What Pushes It Up?

There appear to be three factors that cause flow of the hot waters to the surface. First, much of the recharge area to the northeast is at a significantly higher elevation than the springs, creating a hydrostatic head. Even though the water descends to great depth, it emerges at a lower elevation than it went in. Second, heating at depth causes the water to become buoyant. Finally, the distribution of fractured and folded rock is such that large amounts of rainwater are collected from a broad area and then funneled rapidly up through a much narrower escape route.

The normal increase in temperature with depth in the earth's crust appears to be a sufficient source of heat for the system. This does not rule out the possibility

that some other heat source could be involved, although this appears unlikely. The most recent igneous activity in Arkansas occurred some 90 to 100 million years ago. Although it is possible that one of these masses of igneous rock lies buried at depth beneath the Hot Springs area, any molten material would have cooled long ago and would not now be a likely source of heat.

Thermal Springs Elsewhere in the U.S.



Hot springs in the contiguous states.

Thermal springs occur elsewhere in the United States, particularly where there has been recent volcanic activity. Hot springs, however, are rare in the central part of the continent. An unusual set of geologic conditions of the Ouachita Mountains has created and maintained the flow of hot waters here in a small valley in central Arkansas. How long they will continue to flow is unknown. Management of this resource seeks to insure that the activities of man do not reduce the flow of these waters or alter their chemical quality.

Development of the Spa

The first bathhouses, which were constructed in the late 1830s, were really little more than brush huts and log cabins placed over excavations cut in the rocks to receive hot water that flowed from the springs. More elaborate bathing facilities soon developed, and a complicated series of wooden troughs was constructed to convey hot water from the springs on the hillside to bathhouses located on the valley floor. These bathhouses were built along the east bank of Hot Springs Creek. Some of the tufa covering the hillside was excavated and removed to make room for them. The visitor of that time would cross over Hot Springs Creek via a bridge from the narrow street which ran the length of the valley. The creek, however, had a tendency to flood and was muddy during wet weather, foul during dry. Much unplanned growth occurred before direct federal supervision was exercised in 1877. Shortly after this event, an engineer from Yellowstone National Park was detailed to make major improvements.

The creek was eventually arched over and the space above and on either side filled in, permitting construction of a street 100 feet (30 meters) wide. Diggings, tents, shacks, and rubbish cluttered the area above and between the springs. All squatters were evicted, a few of the springs were encased, and a centralized plumbing system was begun. Individual bathhouses, however, still had ingenious but often unreliable flumes and pipes leading from various springs. Not until comparatively recent times has a unified central collection, cooling, and distribution system been achieved.



Flumes carrying water to Rector Bathhouse, 1867

Differences in the Springs

Individual springs began to gain a reputation for alleviating specific ills. Some of the names given the springs refer to their chemical properties: Magnesia, Big Iron, and Arsenic. Big Iron deserves its designation for the ochreous crusts and stains that precipitate from its water. Arsenic Spring, on the other hand, contains no detectable traces of that substance. An anomalous pair of cold-water springs was named after adjoining organs of the body: Kidney and Liver. Drinking copious quantities of kidney had the predictable effect, but the value of Liver remains obscure. These two springs are no longer in existence.

At one time or another, almost any of the open springs could have gone by the designation, "Mud". This name, however, was reserved for the most viscous of the lot. Mud Spring was a favorite among early bathers, who could ease themselves into its tepid ooze without fear of getting parboiled. Minor differences in the composition of the individual spring waters do exist but their overall similarity indicates a common origin. All of these waters are now mixed together, and a single water of the same composition is supplied to each of the bathhouses.

Radiactivity in the Springs

In 1905, Professor B.B. Boltwood of Yale showed that the waters contained a measurable level of radioactivity. This radioactivity is due primarily to the presence of dissolved radon gas, secondarily to radium. These two elements come from decay of tiny traces of uranium and thorium, which are scattered throughout the rocks through which the thermal waters flow. Both radon and radium were considered in the past to have curative properties. As a result, collection and distribution equipment was specifically designed to retain the radon gas. Today we recognize that it is probably not healthful to be exposed to uncontrolled radiation of any kind. The radon gas, however, is initially present in extremely small quantities,

and most escapes into the air space in the storage reservoirs before the hot waters are pumped to the bathhouses. The level of exposure to radiation that results from bathing in these appears to be similar to the level that would result from sitting in the sun for the same period of time. A greater exposure may result from drinking the water. Even though water quality standards for public supplies have been considerably tightened in recent years, park water is considered well within safe limits. Other natural waters within the region and throughout the world have similar levels of radioactivity. However, our attitude has changed completely from the days when it was exciting news to hear that Hot Springs waters have radioactivity levels comparable to those of fashionable European spas.

Evidence of Past Springs

The modifications which have been made to the Valley of the Hot Springs over the years are a natural consequence of public interest in the use of the hot waters for medicinal bathing and of government desire to protect and manage this resource in an equitable manner. Because of the physical changes which have resulted, however it is difficult for today's visitor to imagine what the springs must have looked like in their original state. Most of the springs are covered over, and their water now runs through underground pipes rather than filtering down over the hillside. Hot Springs Creek flows through a tunnel beneath Central Avenue. The valley floor has been filled in to make it flatter and wider. Large areas of tufa have been removed or covered over. Exotic varieties of plants have been introduced into the area.



Artist's conception of the early hot springs

One of the most outstanding sights in the Valley of the Hot Springs was the massive blanket of calcareous tufa on the side of Hot Springs Mountain. Vestiges of the tufa can still be seen in several places in the park. It is exposed at the open springs behind the Maurice Bathhouse and forms the cliff in back of the north end of Bathhouse Row. DeSoto Rock, across from the Arlington Hotel, is a large block of tufa that has tumbled down from the steep cliff just to the east.

Another interesting exposure of tufa is located on the hillside above the Grand Promenade near the north gates to the Rehabilitation Center. This is far above present hot spring activity. Here lies a broad dome of porous calcium carbonate about three feet (one meter) thick where it is cut by the old carriage roadway. The deposit overlies from 2-6 inches (5-15cm) of a black silty material probably an old soil layer. This dome may represent some of the oldest tufa in the park. We do know that the springs which deposited it were extinct by the time of Dunbar and Hunter's visit in 1804.

The tufa cliffs are no longer forming because most of the hot water is now diverted. Nature cannot be controlled, however, and some calcium carbonate now precipitates out in the pipes and reservoirs of the park's hot water collecting system.

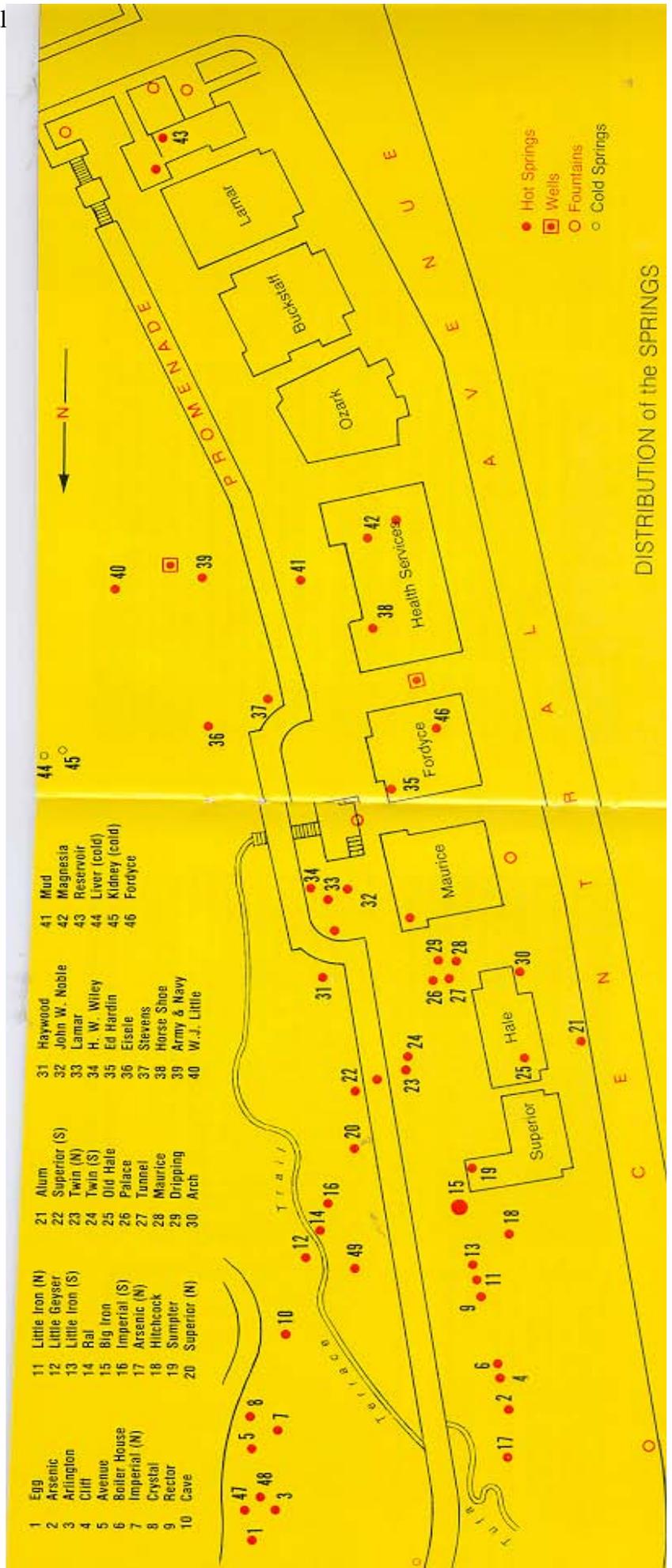
Variation of the Springs

The individual springs vary in the amount of water they discharge. Some are mere seeps. The total amount of water discharged by the hot springs as a group averages 700,000 gallons per day. Studies by the U.S. Geological Survey show that discharge is highest in winter.

The temperature of the spring water averages about 143°F (61°C). There is some seasonal fluctuation due to annual

variations in surface ground temperatures and the inevitable mixing of spring water from seepage from rainfall. Maximum water temperatures have declined about 5°F (3°C) since records have been kept. Dissolved silica content, which is also a measure of maximum water temperature, has also declined slightly. Perhaps the heating system at depth is cooling gradually, or perhaps there has been greater mixing with surface waters.

Distribution of the hot springs in Hot Springs National Park



The protected hot springs lay beneath green boxes like this one.



Rocks of Hot Springs National Park

These are the *primary* rock formations found in Hot Springs National Park. Each formation may also include other rocks. In parenthesis is an easily reached outcrop location.

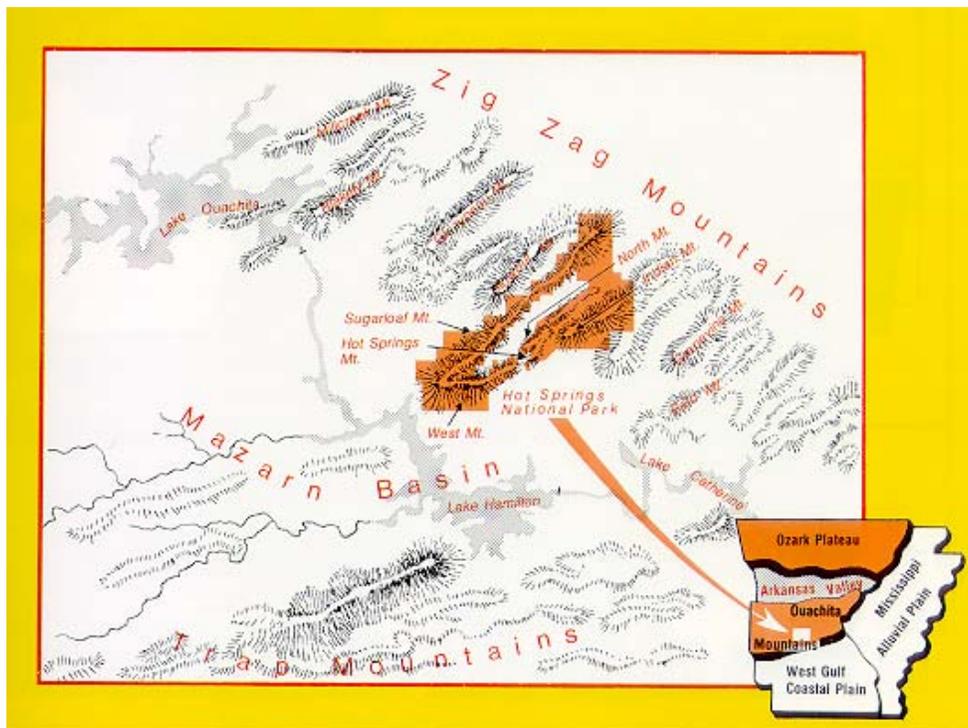
Stanley Shale (West Mountain)—Although deposited more than 200 million years ago, this is the youngest of the park's rock formations. It is black, clayey, and breaks into thin plates. Where exposed, it weathers to pale green, yellow or brown.

Hot Springs Sandstone (West Mountain, North Mountain, Campground)—This hard gray rock, composed of quartz grains, was deposited more than 260 million years ago. Many of the cracks in it are filled with white, or milky, quartz.

Arkansas Novaculite (West Mountain)—Found in all sections of the park, this is the Ouachita Mountains' most distinctive rock. Dense and very fine grained, it is typically bluish white in color, but is sometimes gray, green, brown, yellow, pink, or black. American Indians used it for tools and weapons, and modern man prizes it for whetstones for sharpening knives and tools. This mystery rock (geologists disagree about its origin) tends to stand out on ridges, as softer rocks wear away from around it. It is most abundant in the area between Little Rock and Mena, Arkansas.

Missouri Mountain Shale (West Mountain)—This soft, clayey rock is dark green or black, and contains tiny flakes of mica and small crystals of iron pyrite, or fool's gold. It is believed to have been deposited more than 300 million years ago.

Polk Creek Shale (West Mountain)—This rock is composed of thin black layers of material varying in consistency from soft to slaty. Where exposed it weathers to soft gray stone or changes to clay. Fossilized graptolites are found in Polk Creek Shale, indicating that it was deposited 350 to 400 million years ago.



Hot Springs National Park is located in the Zig Zag Range of the Ouachita Mountains.