GEOLOGY OF THE AREA

Hot Springs National Park is situated in the approximate geographical center of the state of Arkansas, 50 miles southwest of the capitol city of Little Rock, and about 75 miles east of the Oklahoma state line.

Located in southeastern Garland County, it is on the boundary between the Zigzag Mountains (a range of the Ouachita mountain system) and the Mazarn basin. The adjoining mountain ridges are part of the Zigzag mountains which lie in a belt extending approximately six miles west-northwest and nineteen miles east-southeast of Hot Springs. The mountains are more or less continuous zigzag ridges whose individual trends are preponderantly in a northeast-southwest direction. The mountain tops stand on the average 500 feet above the general level of the Mazarn basin, and their highest elevation is 1,200-1,220 feet at the western end of West Mountain, just outside the park boundary. The Mazarn basin and the southern flanks of the Zigzag mountains drain to the east through the Ouachita (Wash-i-taw) River and its tributaries. The northern flanks of the Zigzag mountains drain to the northeast and east through the Saline River and its tributaries.

By interpreting the nature and relationships of rocks and their fossil and mineral contents, in the light of what is happening on the earth's surface today, geologists have gradually pieced together a remarkable geological history of the earth that extends back immense ages of time. An explanation of the hot springs logically begins with a summary of the geological history of this region, including the processes that eventually produced our present topographical features.

With respect to origin, all of the rocks of the Ouachita mountains, with the exception of several igneous intrusions of moderate extent, are of marine sedimentary formations, deposited in horizontal layers on the floor of an ancient sea over a period of millions of years, during the Paleozoic era of geologic time. During most of the Paleozoic era, this present mountainous region was submerged by the waters of the Ouachita Embayment which was a westward-extending arm of the Appalachian geosyncline, an ancient sea located roughly between Louisiana and New Hampshire. To the south of this gradually sinking Ouachita Embayment area of western Louisiana, Texas, and southern Arkansas and Oklahoma, lay the land of lofty mountains known as Llanoris. The eroding rocks of the northern Llanoris were carried northward by rivers and streams into the Ouachita Embayment and deposited there as gravel, sand, mud, and chemical precipitates. Throughout the hundreds of millions of years believed to have passed during the Paleozoic era, these sediments continued to accumulate until they reached the remarkable thickness of over 30,000 feet. This deposition all occurred in comparatively shallow water, accompanied by a gradual corresponding sinking of the ocean floor.

In late Pennsylvanian time there came a period of mountain-making compressive forces from the ocean to the south and southeast applied against the thick sediments and raised their surface above sea-level. In this elevation, the rocks were compressed so severely that they now occupy but one-half their original surface area. A width of 100 miles or more was reduced to the present average 50 mile width of the Ouachita mountains. This compression produced a series of folds, or anticlines and synclines. Where they were unable to withstand the strain produced by the enormous pressure, the rocks fractured, and often adjacent masses moved up and down, respectively, along the break, or fault plane.

The rocks of the Hot Springs area have remained above sea-level during most or all of the time since their emergence near the end of the Paleozoic era, and have been subjected to subaerial erosion from that time. This erosion did not proceed steadily. At least twice, this area was reduced to low-lying land of such low relief that erosion practically ceased. Areas at this stage are known as peneplains. There always followed an uplift, which resumed the erosion process. The first of these peneplains, now evidenced by the higher mountain crests, occurred at the end of the Jurassic period; and the second, evidenced by the present intermountain basins, developed in early Tertiary time. Horizontal layers of sediments beneath an inland sea were lifted many thousands of feet above sea-level, compressed and folded into one-half its original space. The lofty ridges were cut down until they are now valleys.

THE HOT SPRINGS

Practically every visitor who comes to Hot Springs National Park is curious about the origin and mechanics of the hot springs. Until several centuries ago, supernatural agencies were credited with the cause for such phenomena as large streams of hot water gushing out of the earth. Evil monsters were a favorite explanation of incomprehensible occurrences in nature. Later, the water of springs, and expecially of hot springs, was believed by many to be forced up by the winds produced by immense subterranean fires. Misconceptions of volcanoes gave credence to this idea of fires beneath the earths surface. Today, with the development of geology, we know that hot springs may have one or a combination of various sources of heat.

It is believed by probably the majority of geologists that the highly fractured Bigfork chert formation is the aquifer upon which rain water falls and flows through, between the collecting area and the spring outlets. The Womble shale below, and the Polk Creek shale above retain the water within the chert formation. Analysis of the hot spring water would indicate that the water is at least chiefly meteoric (rain) in origin. The minerals in solution, with possibly one exception, are those which would be expected in rain water that has flowed through rocks of the kind that occur in the spring area. Furthermore, the geologic structures required by the meteoric theory seem to be present.

From the collecting area, the water flows down southeastward in the Bigfork formation beneath the lowest part of the trough of the fold (syncline) which lies below West Mountain. The water is then forced upward by hydrostatic pressure along the western part of the upturned fold (anticline) which makes up Hot Springs Mountain. The springs emerge from the base of the Stanley shale and the top of the Hot Springs sandstone. This requires the water to pass through the Polk Creek shale, Missouri Mountain shale, Arkansas novaculite, and most of the Hot Springs sandstone. The logical assumption is that this transfer is accomplished along a fissure, or fault, at the site of the springs. Indications are favorable for the existence of this fault. The abnormally high temperature of the spring water is its most unusual characteristic. To account for the source of heat, we must rely on hypotheses because of the lack of any definite diagnostic criteria.

The generally accepted belief today seems to be that the spring water, somewhere in its underground course, passes near a hot igneous intrusion that has not been exposed at the earths surface. Possibly the water is heated chiefly by rising hot vapors emanating from this cooling mass of igneous rock. This possibility is supported by the trace of boron which has been found in the water. Steam would be a principal constituent of these vapors and in condensing would add to the meteoric water of the springs. Some geologist attribute all or most of the water to this juvenile source. It may be that the water merely approached near enough to the buried igneous mass to heat the water by conduction and convection.

There are several areas of exposed igneous rock and numerous dikes in the vicinity of Hot Springs National Park. These are supposedly related to the larger intrusives. This igneous rock material is believed to have been intruded into the sedimentary formations near the end of the Lower Cretaceous epoch. Presumably any heat of such ancient igneous activity would have been dissipated before now. Consequently, it is not maintained that the exposed igneous masses represent a part of the identical magmatic body which supposedly heats the spring waters.

Probably the chief objection to this theory explaining the origin of the springs is the apparent inadequacy of the collecting basin to supply the large volume of water which the springs produce. The fact that part of the collecting area has an elevation lower than that of some of the springs has also been used as evidence against this theory. However, it has not been shown that an adequate supply of water at sufficient elevation does not exist.

It has been suggested that subterranean chemical activity produces the heat, but this is not borne out by analysis of the water. It would be expected to find unusually large amounts of mineral matter, in solution or minerals different from those ordinarily extracted from the containing rocks by solution in water. Radioactivity has also been repeatedly suggested as a source of heat. There has been no definite evidence to substantiate this hypothesis. Compression of rocks during periods of intense stress, such as obtained during periods of mountain-making produces heat, by any such connection between the hot springs and the orogency of this region is too remote.

The Hot Springs, about 47 in number, are all located along the base of Hot Springs Mountain, and produce a flow of approximately 1,000,000 gallons daily. The largest spring, the Big Iron Spring, located at the south end of the Arlington lawn, has a daily flow of 201,600 gallons according to measurements made by Haywood. Smaller springs range down to as low as 511 gallons per day. Each of the springs from which waters for bathing and drinking are collected is carefully sealed to prevent contamination. Collecting pipes from all of these springs converge into mains, bringing all of the hot water into the large oval-shaped underground collecting reservoir behind the Administration Office Building, at the south end of Bathhouse Row. Adjacent to this huge subteranean vat is a pump room housing two powerful electrically powered centrifugal pumps, each capable of handling 3,600 gallons per hour. These pumps lift the water directly to a two-compartment reservoir with a combined capacity of 400,000 gallons, ingeniously concealed beneath a carefully landscaped slope above the first lap of the paved road on the west slope of Hot Springs Mountain. This reservoir is at an elevation of 720 feet, 119 feet above Bathhouse Row, providing a strong gravity flow to all of the down-town bathhouses.

In order to provide pressure sufficient to supply bathhouses located more remotely, and at higher elevations, an auxiliary pump in connection with the main gravity reservoir lifts some of the water from this main reservoir, up to a 100,000 gallon high pressure reservoir beneath the slopes farther up the hill at an altitude of 820 feet.

The operation of the water system is a model of efficiency.

Electrically operated and automatically controlled, the pumps "kick-on" when the water levels in the reservoir are lowered. Measurement of temperature of the water is constant by use of a continuous operating recording thermometer. The insulation of the piping is so effective that water averaging 143° temperature in the main collecting reservoir, is delivered to the tubs in the bathhouses on the park area at a temperature of only about 4° cooler.

Since the temperature of the water delivered to the various bathhouses is still too hot for bathing, and since on exposure to air the mineral content precipitates, and the radioactive gas (radon) passes from the water, a system was devised whereby the hot springs water was passes through a series of tubes, which were surrounded by cool water and by a transfer of heat from the hot to the continually circulating cool water, the hot spring water was cooled without exposure to air, and this cooled water piped to the various bathhouses to temper the baths for proper bathing. The natural hot spring water is never in actual contact with this cooling water and therefore retained its purity, losing only several degrees of heat.

Whatever the source of the water and its heat, the springs continue to have a constant daily flow of almost a million gallons of water with a constant temperature of over 143° F., and the combined water from the several springs impounded in a central collecting reservoir possesses radioactivity of .81 millimicrocuries per liter. This radioactivity occurs as radon, a gaseous emanation. The springs with their alleged therapeutic values, were the primary reasons for the initial exploration and settlement in this area, and have regulated the growth and popularity of the city of Hot Springs, as well as the reputation of Hot Springs National Park as a Spa for thousands of visitors seeking health and recreation.

The chemical content of the natural hot water has been found to be:

(Parts per million)

Silica (SiO_2)................	45
Iron (Fe)...................	.05
Manganese (Mn)...............	.26
Calcium (Ca)................	46
Magnesium (Mg)...............	5.8
Sodium (Na).................	5.1
Potassium (K)................	1.6
Bicarbonate (HCO_3)...........	165
Sulphate (SO_4)..............	9.1
Chloride (Cl)................	2.1
Fluoride (F).................	0
Nitrate (NO_3)...............	0

Gases in cubic centimeters per liter at 0° C. and 760 millimeters pressure: Nitrogen (N), 8.8; oxygen (O), 3.8; free carbon dioxide (CO_2), 6.9; hydrogen sulphide (H_2S), none; Radioactivity, 0.82 millimicrocuris per liter.