NOTE ON AN EBB AND FLOW SPRING NEAR ROGERSVILLE, TENNESSEE[1]

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Definition

An ebb and flow, or periodic spring is defined by Meinzer[2] as follows:

"A *periodic spring* is a special kind of a spring which has periods of relatively great discharge at more or less regular and frequent intervals. Periodic springs resemble geysers somewhat in their rhythmic action but are due to entirely different cause. All, or nearly all, occur in regions underlain by limestone, and their rhythmic action has been supposed to be due to natural siphons in the rocks. Periodic springs may be perennial or intermittent."

Occurrence

Ebb and flow springs, to use the more common name, are not numerous and usually arouse considerable interest in those acquainted with them. Frequently the residents in the vicinity of one of these springs claim that it is the only one of its kind in the world and describe it as one of the "world's wonders." However, Bridge[3] notes 16 periodic springs which occur in the United States and in Europe. To this number Meinzer[4] has added about a half dozen, all of which are in the United States. This enumeration includes no ebb and flow springs in Asia, Africa or Australia, but it is probable that springs of this type also occur in these continents. Doubtless, there are many unreported periodic springs, not only in the United States, but also in the rest of the world. The Rogersville ebb and flow spring is the first one reported in the state of Tennessee.

The Rogersville Ebb and Flow Spring

The Rogersville ebb and flow spring, which is the reason for this note, is situated 3.8 miles northeast of Rogersville, Tennessee, on the property of C. J. Beal on an unnamed tributary of Big Creek. This spring issues from several openings beneath limestone ledges at the base of a steep hill, as shown in Plate I, and is surrounded by a number of beautiful trees. Adjacent to the spring is a dairy which makes use of it as a water supply. The discharge of the spring, together with the flow of the unnamed tributary, is diverted by a

[1]Published with the permission of the Director of the U. S. Geological Survey.
[2]Meinzer, O. E., Outline of ground water hydrology with definitions: U. S. Geological Survey Water Supply Paper 494, p. 54, 1923.
[3]Bridge, Josiah. Ebb and flow springs in the Ozarks: School of Mines and Metallurgy, University of Missouri, Bulletin, Vol. VII, No. 1, pp. 17-26, November, 1923.
[4]Personal communication.

small concrete dam into a mill race and over an overshot wheel which operates a small grist mill.

At each of the writer's visits to the spring, the spring was sluggish and rose and fell very deliberately without any gurgling, bubbling or roaring. The period of maximum discharge started almost imperceptibly and the level of the water continued to rise for eight or nine minutes to a maximum height of four inches and then gradually declined for the next fifty minutes until the ordinary flow was established. The period of increased flow was about one hour. The estimated discharge of the spring was about fifty gallons per minute at the moment of maximum discharge with a gradual decrease during the next sixty minutes and about ten gallons per minute during minimum discharge. The temperature of the water is 56° F.

The writer has been unable to spend any great period of time in the vicinity of the spring and has been dependent upon the residents in the vicinity and the workmen in the dairy for information concerning the activities of the spring. Most of the people interviewed insisted that the period between maximum discharges is always two hours and forty minutes with no variations in yield at the periods of maximum and minimum discharges. However, one man casually mentioned that sometimes the spring did not rise so high as at other times. Until a recording gage is installed it will be difficult to obtain much accurate data concerning the period of this spring. None of those questioned reported any reversal of flow.

Geology of Rogersville and Vicinity

Rogersville is in the northeastern part of the Morristown Quadrangle[5] at the extreme eastern edge of the area described in the folio. The spring is in the northwestern part of the area described in the Greeneville Quadrangle.[6] The region is underlain by Paleozoic rocks which range in age from Cambrian to Mississippian. These rocks, which were originally laid down in an approximately horizontal position, were folded in late Paleozoic time. These folds were eroded to base level during Mesozoic time, subsequently raised in a series of relatively rapid uplifts with intervening periods of little diastrophic activity, and accompanied by erosion which has carved the region into a series of parallel ridges with intervening valleys. The resistant layers, chiefly sandstones and cherty limestones, form the ridges, while the valleys are underlain by the purer limestones and shales.

In the immediate vicinity of the spring the only rocks exposed are the Maryville limestone and the Nolichucky shale, which are Cambrian in age. The Maryville limestone, the older of the two formations, is described by Keith[7] as a massive blue limestone from

[5]Keith, Arthur. Morristown folio. (No. 27), Geol. Atlas U. S., U. S. Geol. Survey, 1896.

[6]Keith, Arthur. Greeneville folio. (No. 118), Geol. Atlas U. S., U. S. Geol. Survey, 1905.

[7]Keith, Arthur. Loc. cit.

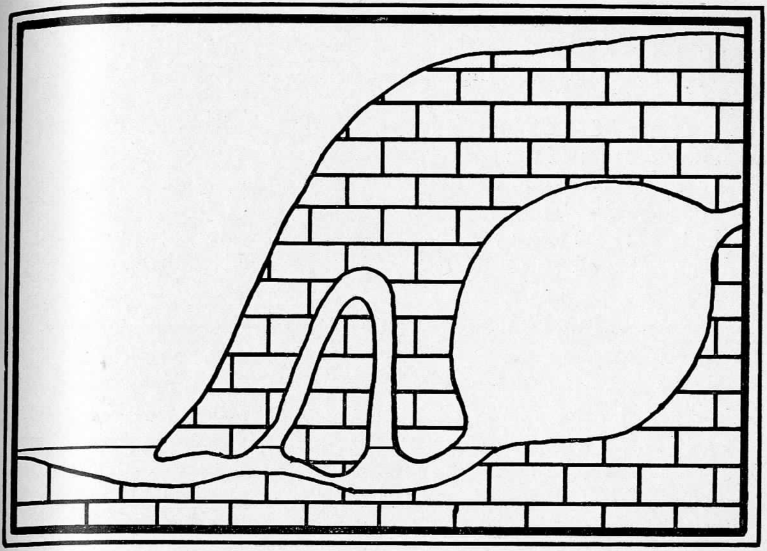

Figure 1.—Hypothetical cross-section through Rogersville Ebb and Flow Spring.

700 to 950 feet thick which is relatively soluble and in which solution channels readily form. The Nolichucky shales consist of a mass of yellow and greenish-yellow calcareous shale with subordinate amounts of thin bedded limestone. In general, the Nolichucky shale is less previous than the Maryville limestone, particularly where the latter is more or less honeycombed with solution channels. However, some of the limestones in this shale formation are readily soluble, and an excellent spring issues from a solution channel about 300 yards downstream from the ebb and flow spring.

FAULTING

During the folding the forces were, in places, greater than the strength of the beds with result that the beds were ruptured and the ends of the strata were displaced. Faults are numerous in the vicinity of Rogersville and both normal and reverse faults are shown on the geologic map in the folios previously mentioned. The geologic map in the Greeneville Quadrangle[8] shows a normal fault in the vicinity of the spring. The map shows that this fault strikes approximately northeast by east and this fault is easily recognized in the field. The strike of the Maryville limestone is about N. 30° E. and the dip 20° S. E., while the strike of the thin bedded limestones in the Nolichucky shale is approximately N. 45° E. and the dip 25° S. E. Although the trace of the fault is very clear on the steep hill-side the dip of the plane could not be observed. The field evidence points to a dip to the southeast at an angle of less than 30°.

[8]Loc. cit.

The spring is situated less than 25 feet from the fault and it is highly probable that the fault had much to do with the location of the spring. The breaking of the brittle Maryville limestone and the thin-bedded limestones of the Nolichucky shale together with the presence of the impervious shale beds has doubtless much to do with the location of the spring. The water can circulate through the fractured and channeled limestone but is impounded by the impervious shales. The unnamed tributary of Big Creek which crosses the beds at right angles to the strike has cut a deep, youthful valley and has afforded an outlet for these impounded waters.

A Reported Ebb and Flow Spring Near Lenoir City, Tennessee

While investigating the Rogersville ebb and flow spring the writer heard of a spring near Lenoir City which was reported to ebb and flow. The writer visited the spring immediately and found it to be a limestone spring situated in a sharp re-entrant at the base of a steep hill, at a distance of approximately 100 feet from the county highway which parallels the tracks of the Southern Railway, three miles northeast of Lenoir City. Observation of the spring failed to indicate any rhythmic variation in discharge. Inquiry among the residents in the vicinity furnished some data on the spring. A young farmer who had lived in the vicinity for more than fifteen years reported that the spring had always been an ebb and flow spring with a period of approximately 20 minutes between maximum discharges and that usual variation between "high and low water" was about three inches, until about three years ago. He also said that the spring rose rapidly with very little noise then almost completely ceased to flow, then continued to discharge as a "small stream," but he was unable to estimate the maximum discharge. Several years ago the highway was improved and the grades changed. In making a fill near the spring adequate care was not taken to furnish proper drainage at the former surface elevations and, apparently, the spring was partly flooded. Moreover, no effort was made to protect a small sink hole through which the discharge of the spring disappeared. The clogging of this sink hole necessitated the digging of a ditch to drain the water from the spring into a nearby creek. The clogging of the sink hole and the backing of water into the spring are supposed to have ruined the rhythmic discharge. Another farmer in the vicinity reported substantially the same facts but he claims that he still observes a period of "high water" between 7 and 8 A.M. He passes the spring regularly each day on his way to his barn and although he passes that way at frequent but irregular intervals he has not seen a change of level at any other time. A bare strip of rock about 2½ or 3 inches wide between the surface of the water and the lower limit of growth of moss at the time of the writer's visit indicated a possibility of alternate wetting and drying of this strip due to rise and fall of the water level.

Plate I.—Spring at Minimum Flow

The definition says that periodic springs may be perennial or intermittent. The Tide spring near Broadway, Virginia, is intermittent and is reported to have been dry as long as two years and then resumed its periodic character. While this spring has not gone dry there is a possibility that this continuous flow is but a phase of its periodic discharge. However, one man working on the highway expressed an opinion that he thought the spring had stopped its periodic discharge due to high water in the river. The owner of this spring is cleaning and deepening the ditch which should prevent the flooding of the spring and may restore its rhythmic discharge. This spring will be visited occasionally to see if it regains its "ebb and flow" discharge and, if possible, to discover the cause of the lapse.

CAUSE OF RHYTHMIC DISCHARGE

Most authorities ascribe the rhythmic discharge to the presence of natural siphons which are connected with subterranean reservoirs. The Rogersville spring does not present any evidence that contradicts this theory. The rise of the water in this spring is slow, and the fall is very slow compared to the rise and fall in artificial siphons with impervious walls. The walls of this natural siphon and reservoir, however, are not smooth. They are limestone with numerous fractures, joint planes and solution channels into which the water penetrates. The slowness in reaching maximum discharge may be due to the water entering such openings and the maximum height

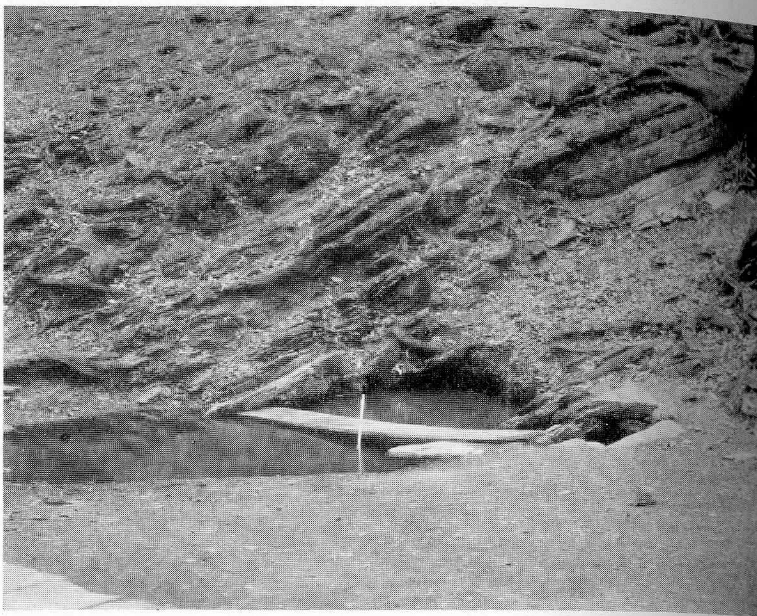

Plate II.—Spring at Maximum Flow

is probbaly not reached until these openings are filled. The very gradual decrease in discharge may be due to the loss of head in the siphon together with the slow percolation of water in the adjacent openings.

A Laboratory Model of an Ebb and Flow Spring

The problem of making a laboratory device to demonstrate periodic flow is simple. The materials needed can be obtained in any chemical laboratory. A container with an opening at the top and one at or near the bottom is necessary, and the lower section of a Kipp Generator is very convenient. A rubber stopper and a glass tube are inserted in the lower opening. The glass tube is connected to a "Y," one arm of which is connected to a siphon and the other to a fine drawn discharge tube which permits water to escape more slowly than it is introduced into the top of the container from the city supply. Consequently the water will rise until the siphon starts action. Then, if the siphon removes water from the container more rapidly than it is introduced from the city supply, the water level in the container will fall until the siphon ceases to operate due to sucking air with the collapse of the unsupported column of water in the siphon.

The most trying operation is to get the proper rate of influx for the combined capillary and siphon discharges. However, with a little patience the adjustment can be made, and the model demonstrates in a striking manner the idea of a single siphon as the source of the augmented flow. In the laboratory device by careful adjustment the starting and stopping of the period of augmented flow can be so regulated that it is much less abrupt than with less careful adjustment.

CONCLUSION

The simplest explanation of the ebb and flow or periodic spring is that it is due to the action of natural siphons which periodically discharge water that has collected in a natural reservoir. The inequalities and openings in the walls account, in part, for the difference between the action of these springs and artificial siphons. The laboratory model is useful to demonstrate the principle but is inadequate to explain all the phenomena.