PHYSICS OF THE EARTH—IX

HYDROLOGY

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184, Nevada 174, Wyoming 116, and Oregon 105. The geyser area of Yellowstone National Park, however, exceeds all others in the abundance of springs of high temperature. Indeed the number of thermal springs in that area might be given as several thousand if the individual springs were counted instead of being grouped. Nearly two-thirds of the recognized springs issue from igneous rocks—chiefly from the large masses of intrusive magma, such as the great batholith of Idaho, which still retain some of their original heat. Few if any, on the other hand, derive their heat from extrusive lavas.

In the paper above cited it is estimated that the total flow of all thermal springs in the United States is not more than 500,000 gallons a minute, which is equal to 720,000,000 gallons or about 2,700,000 cubic meters a day. The average discharge of 177 thermal springs in California on which data are available is 91 gallons a minute. The largest thermal spring in the United States is probably Warm Spring, in Montana, which has a temperature of only 68°F. (20°C.) but has a discharge of about 80,000 gallons a minute, which is equal to about 115,000,000 gallons or 440,000 cubic meters a day.

Size of springs

What is a large spring? This question will be answered very differently in different localities. In localities of small springs the designation "Big Spring" is doubtless borne by springs that yield no more than 10 gallons a minute, and in many parts of the United States a spring that discharges 1 second-foot—that is, 1 cubic foot a second, or 448 gallons a minute, would be regarded as a remarkable spring. On the other hand, in regions of truly large springs, springs yielding at the rate of several second-feet are sometimes called small springs.

In 1923 the writer [25, p. 53] called attention to the need for a classification of springs according to their rates of discharge and proposed two systems of classification—one based on the metric system and the other on the units commonly used in the United States. The second system, which has come into use, especially with respect to very large springs, is outlined in the following table:

Classification of springs with respect to size, based on units used in the United States

Magnitude	Discharge
First	100 second-feet or more.
Second	10 to 100 second-feet.
Third	1 to 10 second-feet.
Fourth	100 gallons a minute to 1 second-foot (448.8 gallons a minute)
Fifth	10 to 100 gallons a minute.
Sixth	1 to 10 gallons a minute.
Seventh	1 pint to 1 gallon a minute.
Eighth	Less than 1 pint a minute (less than 180 gallons or about 5 barrels a day).

In the United States there are doubtless thousands of springs of the third magnitude, as defined above, and hundreds of springs of the second magnitude. According to a study made by the writer [27, p. 47], there are in the entire country 65 springs of the first magnitude, of which 38 rise in volcanic rocks or associated gravel, 24 in limestone, and 3 in sandstone. Of the first-magnitude springs in volcanic rocks or associated gravel, 16 are in Oregon, 15 in Idaho, and 7 in California. Of the limestone springs, 9 rise in Paleozoic limestone (8 of them in the Ozark area of Missouri and Arkansas), 4 in Lower Cretaceous limestone (in the Balcones fault belt in Texas), and 11 in Tertiary limestone (in Florida or adjacent area). The 3 springs that issue from sandstone are in Montana. They are believed to owe their great discharge to faults or to other special features. With the additional data now available some revision of these figures could be made, but it would be of minor character.

The recorded discharge (generally the average of available measurements) of a few of the largest springs and groups of springs is given in the following table:

Recorded discharge of very large springs and groups of springs in the United States

	Cubic feet a second	Gallons a day	Cubic meters a day
Springs in volcanic rock or associated gravel:			
Sheep Bridge Spring, Oreg	323	209,000,000	791,000
Springs along 10-mile stretch of Metrolius River, Oreg	1,070	692,000,000	2,619,000
Springs along 10-mile stretch of Fall River, Calif	1,400	905,000,000	3,425,000
Malade Springs, Idaho	1,133	732,000,000	2,761,000
Thousand Springs, Idaho	864	558,000,000	2,112,000
Springs along 50-mile stretch of Snake River, Idaho	5,085	3,787,000,000	14,334,000
Springs in limestone:			
Big Springs, Mo	428	277,000,000	1,048,000
Comal Spring, Tex	330	214,000,000	810,000
Silver Spring, Fla	808	522,000,000	1,976,000
Spring in sandstone:			
Giant Springs, Mont	600	388,000,000	1,447,000

Fluctuation of springs

Most springs fluctuate greatly in their rate of discharge but some are nearly constant. The fluctuations are produced chiefly by variations in the rate of recharge and in the rate of discharge by evaporation and transpiration, but other influences are also effective. The response to these variations differs greatly in different springs, according to the geologic and other conditions in the areas from which the springs are supplied. Some springs respond promptly and decisively to recharge, others only with