for such source of heat is not entirely lacking in the case of the Virginia thermal waters.

Although the rate of temperature increase with depth is unknown for any of the thermal springs areas, if we assume a temperature increment of 1° F. for each 60 feet of depth and the known mean annual temperature of 50.6° F. as determined by the United States Weather Bureau, most of the heat might be derived from a depth of less than 3,500 feet in case of the hottest waters of the region (Hot Springs, Virginia). The writer is aware that objections, a discussion of which is beyond the scope of this paper, might be urged against increase of temperature with depth as a source of temperature, even though the estimated depth be moderate. However, what the probabilities are from other possible physical sources of heat as controlling factors must await more detailed geologic observations in the different areas.

## THE HOT SPRINGS OF THE REPUBLIC OF HAITI[1]

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The Republic of Haiti (see map, Fig. 1) contains a number of warm springs of considerable interest. These are commonly known by the generic name of *sources chaudes* (warm springs), local geographical names being added to distinguish them from one another. Four of these groups of springs will be described in order as numbered in Figure 1.

### 1. WARM SPRINGS OF TERRE-NEUVE, OR EAUX BOYNES

The Eaux Boynes, also known as the Sources Chaudes de Terre-Neuve or de Port-à-Piment, are the most celebrated warm springs of the republic. They have long enjoyed a reputation for having great curative properties, particularly for skin diseases and for rheumatism, and so have been much frequented by invalids.

[1] Published by permission of the acting director of the U.S. Geological Survey and the engineer-in-chief of the Republic of Haiti. Abstracted from *Geology of the Republic of Haiti*, by W. P. Woodring, J. S. Brown, and W. S. Burbank. Republic of Haiti Geological Survey. (In press.)

Moreau de St. Méry[1] describes them at length, and tells of their utilization by the French colonists. The springs, and their curative value as well, are said to have been discovered by a negro named Capois in 1725. They soon became a noted rendezvous of health-seekers. In 1772 M. de Raméru, owner of the springs, gave them to the Crown in order that they might be used entirely for the public good. The government erected a military hospital at the

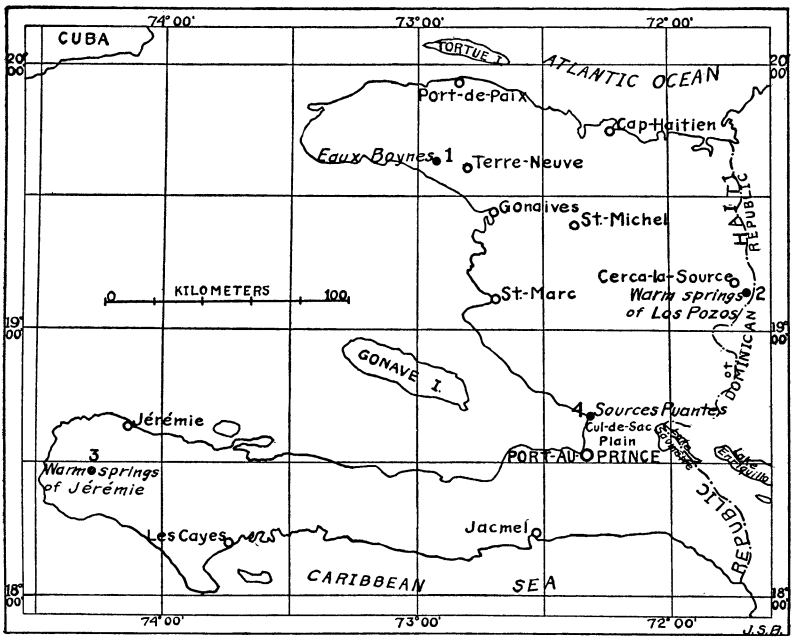


FIG. 1.—Index map showing location of warm springs in the Republic of Haiti.

place, and also a sanitarium open to the public at reasonable rates. There were sixteen masonry baths for the public besides those for the soldiery. Beautiful avenues of trees adorned the place. A passenger boat made bimonthly trips between Cap-Haitien, the Colonial capital, and the landing at Port-à-Piment.

All this contrasts strangely with the present dilapidated condition of the place. Only the ruins of eight of the masonry baths

[1] L. E. Moreau de St. Méry, *Description topographique, physique, civile, politique et historique de la partie Française de l'isle Saint Domingue.* 2 vols. Philadelphia, 1797–98. See Vol. II, pp. 62–75.

remain. There is no trace of the fine buildings, and the avenues of trees are gone. Nevertheless, the springs still make a green and pleasant oasis in what is virtually a desert, and nourish a vicarious planting of cocoanut trees and several thickets of bayahonde. There is a small agricultural settlement, with a few simple, thatched houses, whose inhabitants pasture their animals in the region and irrigate some diminutive gardens near the springs. In spite of the lack of accommodations many persons still visit the springs to test their healing power.

The Eaux Boynes are about 12 kilometers west of Terre-Neuve and 30 kilometers northwest of Gonaives. They are about 8 kilometers from the sea, at the inner edge of a narrow coastal plain. Behind them to the north and east is a narrow belt of low foothills and beyond that a range of mountains which rises abruptly to an altitude of more than 1,000 meters above sea level. The springs themselves are less than 100 meters above sea level.

The relation of the springs to the surface features in the locality is shown[1] in Figure 2.

It is said that formerly there were seven springs, but now only six can be found. It is probable that the other was developed by trenching in a marshy spot, and has since been obscured by débris. Of the six existing springs, five have a remarkably perfect alignment in a direction about N. 55 W. The springs at the ends of this line are about 235 meters apart. The sixth spring is offset considerably to the south of the easternmost spring. Some details regarding each outlet are given in the following paragraphs.

Grossier Spring is on a distinct mound that is situated on the bank of a small dry ravine about 3 meters in depth. The mound is formed of black soil full of humus, and is covered by a thick tangle of trees, chiefly bayahonde (a relative of the mesquite). Water issues mainly from an outlet on the west side of the mound, away from the ravine, but a little also issues on the side nearest the ravine. The flow does not exceed 2 or 3 gallons per minute. The temperature in the little pool at the larger outlet is 49° C. (120° F.) The water is not used.

[1] Part of the illustrations in this report were made up to accompany a French edition and are in French.

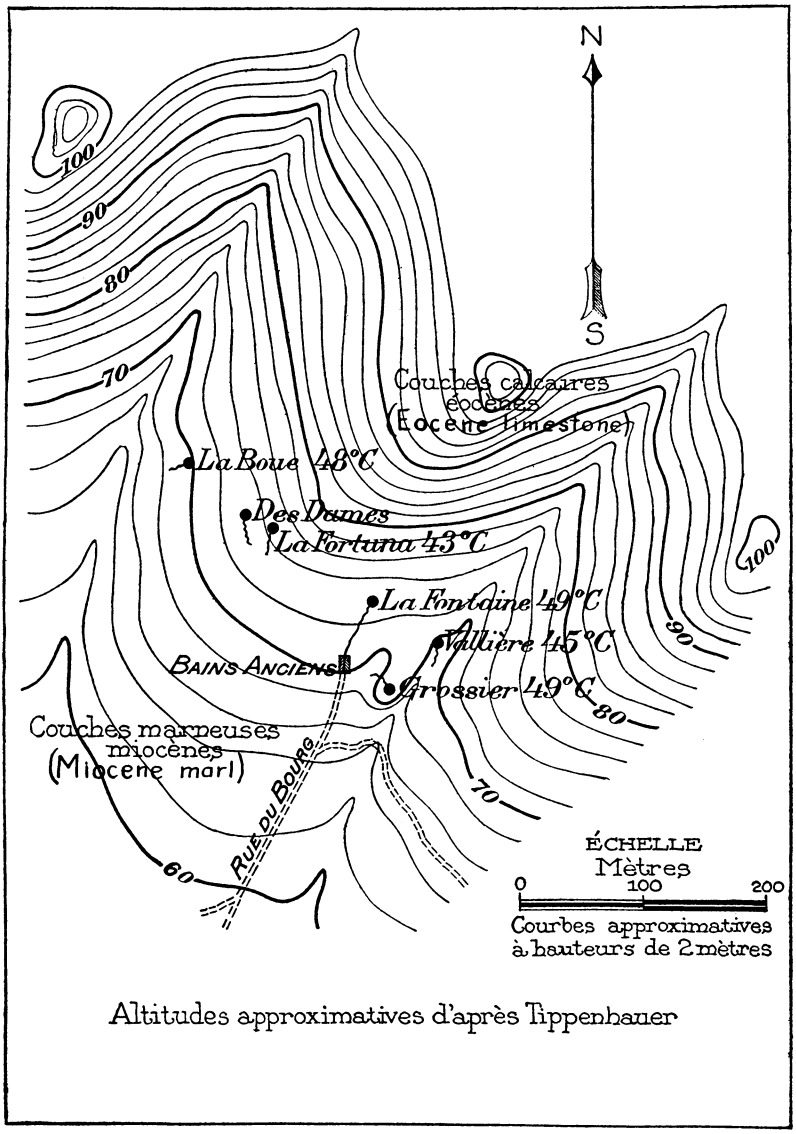


FIG. 2.—Sketch map of the Eaux Boynes, or Warm Springs of Terre-Neuve. (From *Geology of the Republic of Haiti.*)

Vallière Spring is in the bed of a shallow ravine, and issues from a little basin in black soil. It yields perhaps 5 gallons per minute of water with a temperature of 45° C. It is used little or not at all.

La Fontaine rises from a bowl-shaped basin about ½ meter in diameter in black soil. It has the largest flow of any spring of the group, estimated at 10 to 15 gallons per minute. The temperature in the outlet is 49° C. Bubbles of gas rise very slowly, at intervals of several seconds. There is little or no odor, and careful test showed only a trace of $H_2S$. The gas probably is $CO_2$. From the spring the water is led through a canal for 50 or 60 meters to the ruins of the eight masonry baths, and to a fountain and watering trough. Virtually all the water for domestic use and for drinking in the village is carried from this fountain. The water is clear and has a faint, peculiar taste, but is neither unpleasant nor harmful, even when taken warm. An analysis of water from this spring is given in Table I.

La Fortuna and Des Dames springs are covered and issue through short aqueducts. They are used for laundry work and for irrigation. The flow of each spring is less than that of La Fontaine. No temperature reading could be obtained near the outlet of Des Dames, and that at La Fortuna, 43° C., was taken in seep at one side of the broken cover and probably is too low.

La Boue Spring issues from a very small basin in black earth, and flows into a large dirty pool several meters in diameter. Its flow is not more than 4 or 5 gallons per minute, with a temperature of 48° C. Bubbles of gas rise at intervals as at La Fontaine. No particular use is made of the spring.

The line of springs is plainly situated at the break in slope from foothills to plain, but cuts across a low ridge between two ravines, ignoring the minor details of the topography. Geologically the springs appear to occupy a well-defined contact, although only alluvium and residual soil are visible around their outlets. Soft, marly beds of Miocene age, which are exposed less than a kilometer to the south, presumably underlie the whole coastal plain. The foothills, on the other hand, consist of limestone, presumably the lower part of the thick Upper Eocene limestone which covers extensive areas in the mountains to the east and north. This rock is

exposed on a hill about 200 meters northeast of the springs. It is a hard, yellowish-white limestone, poorly exposed, and with indeterminable bedding. The Miocene beds, generally, dip seaward at low angles; the Eocene rocks probably also dip seaward, judging from their relations elsewhere.

The position of the springs at a topographic break and near a geologic contact, and their alignment parallel to the major structural trends of the region, suggest strongly that they issue along a fault zone, and the temperature of the water indicates that it must rise from considerable depth. Further discussion of their origin follows the description of the other groups of warm springs.

### 2. WARM SPRINGS OF LOS POZOS

This description is based upon information supplied by W. P. Woodring. The warm springs of Los Pozos are on the estate of Charles Zamor, in the section of Los Pozos, about 6 kilometers southeast of Cerca-la-Source. They are reported to have therapeutic value, especially in the treatment of skin diseases, but are not much used for any purpose. At two of the five springs there are crude shelters for bathers, but there is no settlement at the springs.

The springs are at the southern border of the valley of Rivière l'Océan and at the foot of a rounded escarpment in Upper Oligocene limestone. Farther northwest, near Cerca-la-Source, this escarpment becomes high and precipitous. There are five springs, four of which are arranged along a straight line trending about N. 70° W., on the northeast side of the trail from Cerca-la-Source to Los Pozos. The local geography is shown in Figure 3. Notes on the separate springs, whose names were not ascertained, follow. None of the springs flows more than a few gallons per minute.

1. Water seeps out along the trail and is conducted about 5 meters down the slope to a wooden tub, hollowed out from a log. Over the tub is a crude shelter. This water had a temperature of 36° C.

2. This is a small seep, not cleaned out. The temperature was 38° C.

3. This is the largest spring of the group, and also has the highest temperature (42° C. = 108° F.). The water issues from an opening

between two large limestone bowlders that have come down the slope. It has a strong odor of hydrogen sulphide ($H_2S$). Algae grow abundantly in the spring. Over it is a crude shelter. An analysis of a sample of water from this spring is given in Table I. Unfortunately no means were available to fix the hydrogen sulphide ($H_2S$), which otherwise evaporates quickly, so that this constituent was not determined.

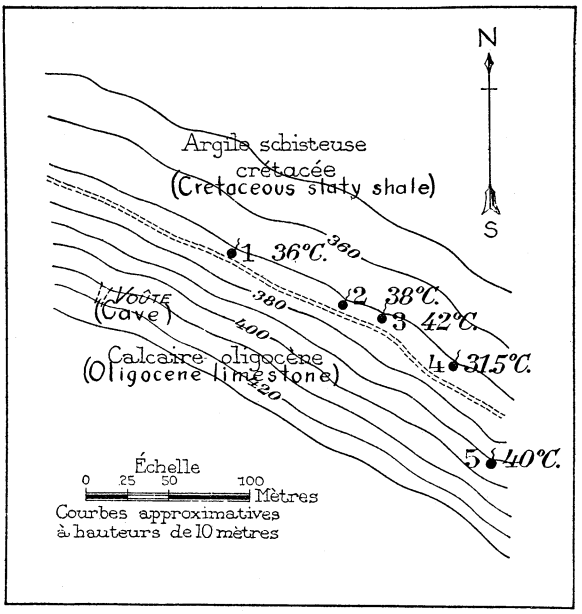


FIG. 3.—Sketch map of the warm springs of Los Pozos. (From *Geology of the Republic of Haiti.*)

4. This is a small spring, and not cleaned out. The temperature of the water was 31.5° C.

5. A trench has been dug in the slope to increase the flow of this spring. The opening is lined with rough limestone blocks. The temperature was 40° C.

As previously stated, the escarpment southwest of the springs is of Upper Oligocene limestone. The valley to the northeast is underlain by semi-metamorphosed shales, supposedly of Middle or Lower Cretaceous age. A fault is believed to exist along the

base of the limestone escarpment. Certainly it seems reasonable to assume that the springs issue along a fault zone, since they are aligned parallel to the contact of the formations and to the strike of the rocks, as well as to the prevailing structural trends. The source of the water will be considered later.

### 3. WARM SPRINGS OF THE SOUTHERN PENINSULA

Several warm springs are known in the interior of the western part of the southern peninsula of Haiti. According to Moreau de St. Méry[1] and other writers, warm springs exist at four localities, three on the "Bras-Gauche" or eastern fork of the Grand River of Jérémie, and one on the "Bras-Droit" of the same stream. This latter group of springs is on the headwaters of the Bras-Droit almost in the bed of its deep, narrow valley, and is known as the warm springs of Les Irois or of Anse-d'Hainault. Two groups are near the headwaters of the Bras-Gauche, one group on a tributary ravine about 600 meters west of that stream, and the other group in the bed of the Bras-Gauche about 600 meters downstream from the junction of the ravine. These springs are known as the warm springs of La Cahouane or of Tiburon. According to Moreau de St. Méry, their temperatures were 34° C. and 37.5° C.[2] About two leagues downstream from these springs are the warm springs of Dame-Marie or of Jérémie, evidently the ones visited by the writer and described in the following pages.

All the springs are supposed to have medicinal virtues, and are frequented considerably by persons from this part of Haiti; but the region is so rough and inaccessible that it is very thinly inhabited, and is seldom visited by strangers.

*Warm springs of Dame-Marie or of Jérémie.*—These springs are on the Bras-Gauche, the eastern fork of the Grand River of Jérémie, about 15 kilometers by a very difficult horseback trail above its junction with the Bras-Droit. For part but not all of the way the trail follows the river, which it crosses many times. At the springs are about half-a-dozen thatch shelters used by the transient visitors, but no permanent habitations.

[1] *Op. cit.*, Vol. II, pp. 759–60.

[2] Converted from degrees Réaumur.

The river valley is incised directly across high mountain ranges, and is deep and narrow. At the springs, however, the adjacent mountains are lower than farther north, and probably rise only 500 or 600 meters above the river. The elevation of the springs, according to a rather unreliable aneroid barometer reading, is about 190 meters above sea level.

There are two springs about 50 meters apart on the southwest bank of the river. The one farthest southeast is about 4 meters and the other only about 1.5 meters above the river bed. The lower spring issues plainly from a small fracture an inch or two wide in dark basalt, which is the prevailing country rock. The other doubtless issues from a similar fracture, but its outlet is obscured by débris. The water bubbles up with considerable force at each spring, but no gas bubbles were noted, and only a faint odor. The taste of the water is not unpleasant. No thermometer was available, but the temperature of the water probably is between 35° and 40° C. One can hold the hand in either spring indefinitely, without discomfort, whereas a few seconds is the limit at Eaux Boynes (49° C.).

There are no bathing facilities, except a sort of earthen-walled, rock-floored basin scooped out at the lower spring, and a quaggy area of mud at the upper spring, which is a favorite place for mud baths.

An analysis of the water is given in Table I, and its origin further discussed in a later section.

### 4. SULPHUR SPRINGS: "SOURCES PUANTES"

A number of springs in the Republic contain notable amounts of hydrogen sulphide ($H_2S$). The distinctive and rather unpleasant odor of the gas is responsible for the name *sources puantes* (stinking springs) frequently applied to them. The most famous of the kind are the Sources Puantes at the northwest corner of the Cul-de-Sac Plain (Fig. 1). The odor of these springs can be detected for some hundreds of meters. Many persons believe the springs to have healing virtues. There is an open basin for bathing, but it seems to be used very little. No one lives near the springs.

The original outlet of the springs has been disturbed somewhat by the building of a railroad embankment and highway crossing.

At present the largest flows of water issue from two small basins at the lower side of the embankment. Some water appears to seep out over a large marshy area about 100 meters in diameter. The flow of the springs is large, but difficult to estimate. The two large openings alone must yield 500 gallons per minute or about 1 second-foot. Bubbles of gas rise almost continuously both at the larger openings and at spots on the adjacent marshy area. Presumably, most of it is hydrogen sulphide ($H_2S$). This was fixed in the form of cadmium sulphide (CdS) by adding cadmium chloride ($CdCl_2$) to the sample, analysis of which is given in Table I. The water is appreciably warm, its temperature in December being 32.7° C. The taste of the water is salty and nauseating, although its appearance is clear and inviting.

TABLE I

ANALYSES OF WATER FROM THE WARM SPRINGS OF HAITI*

(Analyzed by C. S. Howard. Data are Parts per Million)

| | 1 Eaux Boynes (La Fontaine) | 2 Los Pozos (No. 3, Fig. 3) | 3 Warm Springs of Jérémie | 4 Sources Puantes |
|---|---|---|---|---|
| Total dissolved solids | 403 | 1,214 | 515 | 12,684 |
| Silica ($SiO_2$) | 35 | 15 | 68 | 36 |
| Iron (Fe) | 0.30 | 0.13 | 0.07 | 0.08 |
| Calcium (Ca) | 51 | 118 | 26 | 397 |
| Magnesium (Mg) | 21 | 33 | 1.4 | 299 |
| Sodium and Potassium (Na+K) | 56 | 223 | 135 | 3,930 |
| Bicarbonate radicle ($HCO_3$) | 277 | 260 | 93 | 610 |
| Sulphate radicle ($SO_4$) | 68 | 62 | 117 | 872 |
| Chloride radicle (Cl) | 36 | 464 | 121 | 6,627 |
| Nitrate radicle ($NO_3$) | Trace | Trace | 0.42 | Trace |
| Hydrogen sulphide ($H_2S$) | Trace | Odor noticeable | ..... | 136 |
| Date of collection of sample | Aug. 1921† | March 14, 1921 | Nov. 16, 1920 | Dec. 6, 1920 |

* All samples analyzed in the Water Resources Laboratory of the U.S. Geological Survey.

† Original sample broken in transit. This sample collected by Père J. J. Joliveau, of Terre-Neuve.

The springs are virtually at sea level, and the marshy area becomes a mangrove swamp only about 50 meters from the main outlet of the springs, with open salt water only a little farther away. Behind them rise low foothills underlain by Miocene rocks, which near the springs are covered by alluvium and conglomeratic débris. Beyond the foothills are high mountains of the older (Oligocene and

Eocene) limestones. The springs thus occupy a very narrow extension of the Cul-de-Sac Plain—a broad, level plain whose surface formation is recent alluvium, but which is underlain, presumably at no great depth, by Miocene beds.

The structural conditions at the springs are quite obscure. They may possibly issue along some undetermined fault, as faults are known to exist on both sides of the Cul-de-Sac Plain and to have had some share in the formation of the structural trough it occupies. Or they may merely rise because of artesian pressure at this low border of the plain where the alluvial formations become more conglomeratic and more porous. The existence of several artesian springs and numerous flowing wells in the Plain to the south and east accords well with this possibility.

As is brought out more fully later, the writer believes these springs are due to the escape of mixed meteoric and connate sea water under artesian pressure. The hydrogen sulphide probably is generated by chemical reactions during the escape of the water.

## SOURCE OF THE WARM SPRING WATERS

As with many, if not most, hot springs, the source of the water in the hot springs of Haiti is a matter of uncertainty. We have the usual possibilities: (1) meteoric water heated (*a*) by descending to considerable depth, (*b*) by coming in contact with hot bodies of intrusive igneous matter; or (2) magmatic or juvenile water given off by cooling igneous matter. Any degree of admixture of water from the two sources is also possible, of course.

On the assumption of a meteoric source the springs might be expected to exhibit seasonal fluctuations in volume, particularly since the rainfall in Haiti is concentrated very notably into two wet seasons each year. No such fluctuations have been reported, but no careful observations have ever been made of the spring flow. The general characteristics of the springs seem not to have changed materially since the days of the French Colony, a fact that may seem to favor uniformity of flow, especially since many cold springs, such as those which furnish the public water supplies of Port-au-Prince and Cap-Haitien and which clearly are fed by meteoric water, are characterized by very marked fluctuations in volume.

However, it is questionable whether the flow in waters, circulating as deep as these necessarily must, might not be equalized so as to be relatively independent of the seasonal rains.

The temperature of the spring waters, even if no allowance is made for cooling on the way to the surface, would in all cases require them to descend to considerable depth to attain their heat merely by virtue of the earth's thermal gradient. The mean annual temperatures at stations which doubtless correspond closely with those at three of the springs are fairly well known.[1] Assuming an average thermal gradient of 1° C. for each 35 meters of depth, a figure that seems to be conservative from any point of view, the data for determining the depth of circulation are given in Table II.

TABLE II

DEPTH OF CIRCULATION NECESSARY TO HEAT SPRING WATERS

| | Spring | | |
|---|---|---|---|
| | Eaux Boynes (La Fontaine) | Los Pozos Spring No. 3 | Sources Puantes |
| Temperature of spring. Degrees C..... | 49 | 42 | 32.7 |
| Place of comparison..... | Gonaives | St.-Michel | Port-au-Prince |
| Mean annual temperature. Degrees C.. | 27 | 25 | 27 |
| Excess temperature of spring. Degrees C. | 22 | 17 | 5.7 |
| Approximate depth of circulation required to heat water, due to Earth's thermal gradient. Meters..... | 880 | 600 | 200 |

Exact data for the warm springs of Jérémie are lacking, but their excess temperature probably is about 10° C., equivalent, under the assumed conditions, to a depth of circulation of about 350 meters. With all the springs this would require circulation considerably below sea level, especially with the Eaux Boynes, which would be about 800 meters below sea level.

Except for the Sources Puantes, where artesian conditions probably exist, there is no evident structure adequate to account for such a circulation, although the adequacy of obscure structures afforded by fault zones is perhaps possible in all the cases. For the Eaux Boynes there is a suggestion of artesian structure in the

[1] From bulletins of the Séminaire-Collège St. Martial, Port-au-Prince.

seaward dip of the Eocene and Miocene beds, although no impervious cover can be demonstrated to exist in the Eocene limestone, which must be the major factor in any such circulation. Moreover, it is doubtful whether the limestone has the requisite thickness, as the beds exposed near the springs are believed to be the lower part of the series, which rests unconformably on an igneous complex. A sufficient thickness of sedimentary beds may very well exist at Los Pozos. For the warm springs of Jérémie there is apparently no possibility except circulation through massive basaltic extrusives, which only occasionally show good flow lines.

The analyses of the waters are probably not conclusive, though all differ notably from the normal cold spring waters of the Republic. These latter commonly carry less than 300 parts per million of total solids, at least 90 per cent of which is calcium and magnesium carbonate, or bicarbonate with the calcium element preponderant. This results from the great prevalence of calcareous rocks over the country. In both the Eaux Boynes and the Los Pozos analyses calcium and magnesium bicarbonates are still preponderant, though in smaller proportion, and calcium still exceeds magnesium. This seems to suggest strongly that whatever the source of the water, most of this part of its mineral content is derived from the calcareous formations encountered in the latter part of its upward journey. In both these analyses, however, the sulphate and chloride of sodium and potassium are out of all proportion to that found in normal meteoric water, and in the warm springs of Jérémie they are quite the dominant feature. Except perhaps at the Eaux Boynes, these constituents cannot possibly be attributed to a mixture of sea water, either directly or in the connate condition, and there is no apparent source for them in the rocks through which they circulate near the surface. In none of these waters, however, are metals or heavy elements, supposed often to characterize magmatic waters, present in more than minute traces. The presence of undetermined gas, probably $CO_2$, in the Eaux Boynes and the springs of Jérémie, will generally be regarded as favoring a magmatic source.

On general geologic grounds the probability of a magmatic source for at least some of the springs is not unreasonable. The

West Indies were the scene of very extensive Tertiary volcanic activity continued in certain areas, as is well known, to Recent time, although there is no evidence of Quaternary activity in the Haitian Republic. In the Terre-Neuve Mountains, about 12 kilometers from the Eaux Boynes, small intrusions at least as late as Oligocene and probably of Miocene age are known. No other volcanic activity of as late a date is known near any of the other warm springs.

It seems suggestive also that in the general locality of the warm springs of Jérémie there appear to be several other groups of similar springs in an area where it is difficult to find adequate structural conditions for a meteoric source, even in a single case.

The Sources Puantes seem to present a problem considerably different from that of the other groups of springs. In the first place their excess temperature above the mean annual temperature of the locality is much less, and does not necessitate circulation to an unreasonable depth, especially since artesian conditions are known to exist on the Cul-de-Sac Plain near by, where there are numerous flowing wells, several of which are more than 150 meters in depth. The water of these wells also is warmer than the air, although measurements unfortunately are lacking. The wells are mostly several kilometers south or east of the springs, but there seems to be no good reason why flows might not be obtained at some places much nearer the springs, if wells were drilled. The artesian water comes either from Recent alluvial strata, or from the buried Miocene beds beneath. It is supplied mainly from the mountains to the south of the plain, as those to the north are semiarid. Since the chief streams enter on the south side and deposit most of their sediment there, the plain has a gentle northward slope almost to the border of the northern mountains.

Analyses of water from the flowing wells seem to indicate that near the sea they become more saline, due either to admixture of sea water, or much more likely of connate water, present in the strata beneath the plain. Coral reefs present at places on the borders of the plain prove that in Pleistocene time it was submerged, so that undrained connate water might be expected in the deeper beds, especially near the sea.

There can be little doubt that the extraordinary salinity of the Sources Puantes is due chiefly to admixture of sea water either directly or in connate form. The relation of the spring water to sea water is indicated in the following comparison:

TABLE III

COMPARISON OF THE COMPOSITION OF AVERAGE SEA WATER WITH THAT OF THE SOURCES PUANTES

(Percentage of Dissolved Solids)

| | Sources Puantes | Sea Water |
|---|---|---|
| Cl | 53.2 | 55.29 |
| Na+K | 31.5 | 31.70 |
| $SO_4$ | 7.0 | 7.69 |
| Ca | 3.2 | 1.20 |
| $CO_3$ | 2.4 | 0.21 |
| Mg | 2.4 | 3.72 |
| Total | 99.7 | 99.81 |

The percentages of chloride, of sodium and potassium, and of sulphate correspond quite closely, and together constitute a very preponderant amount of the total. The concentration of the Sources Puantes is about one-third that of sea water. The variations in calcium, magnesium, and carbonate are quite within the limits one might expect if two parts of meteoric ground water were mixed with one part sea water, and are in the direction to be expected, namely, increase of carbonate and calcium, with calcium becoming preponderant over magnesium.

The writer prefers to attribute the salinity to connate water rather than the direct admixture of sea water, because in extensive studies elsewhere he has found that sea water can scarcely penetrate clastic sediments in such large amount even very near the shore,[1] and because the presence of connate water is in harmony with the circumstances in the case.

The hydrogen sulphide probably is derived from the sulphate of the connate sea water by chemical reactions through the agency of organic matter known to be abundant in the superficial material about the outlet of the spring and probably present also to con-

[1] See John S. Brown, "Relation of Sea Water to Ground Water along Coasts," *Amer. Jour. Sci.* (5), Vol. IV (1922), pp. 274–94.

siderable depth in the lower beds. Clarke[1] says: "The sulphates of a water by accession of organic matter can be partly or entirely reduced to sulphides, and carbonic acid, acting upon the latter, may expel sulphuretted hydrogen and produce carbonates." Some support is lent to this hypothesis by the fact that the sulphate in the spring water is slightly less than one-third that of sea water, whereas the sodium and potassium and the chloride slightly exceed one-third, indicating possibly that some sulphate has been reduced.

The writer does not wish to imply that this same explanation necessarily accounts for the presence of hydrogen sulphide in other springs of the Island which he has not examined.

## SUMMARY

The Republic of Haiti contains a number of notable warm springs, four groups of which are described in this paper. For the first three of these groups the evidence is not conclusive, but probably favors a magmatic source. The fourth group is believed to represent mixed meteoric ground water and connate sea water in which much hydrogen sulphide ($H_2S$) has been generated by chemical reactions.

[1] F. W. Clarke, *Data of Geochemistry* (4th ed.), *U.S. Geol. Survey Bull. 695* (1920), p. 204.