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THERMAL SPRINGS IN THE UNITED STATES

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THERMAL SPRINGS IN THE UNITED STATES

BY

NORAH D. STEARNS, HAROLD T. STEARNS
AND GERALD A. WARING

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By Norah D. Stearns, Harold T. Stearns, and Gerald A. Waring

ABSTRACT

The earliest extensive studies of thermal springs in the United States were made by physicians. In 1831 Dr. John Bell issued a book entitled "Baths and Mineral Waters" in which he listed 21 spring localities. In the edition of his work published in 1855 the number was increased to 181. The earliest report on a geologic study of thermal springs was that of W. B. Rogers in 1840 on the thermal springs of Virginia. In 1875 G. K. Gilbert published a map and table showing thermal springs in the United States and pointed out that they are present chiefly in the mountainous areas of folded and faulted rocks. Early geologic study of them was principally inspired by the information which they afford at a few places on the deposition of minerals. The relation of hot springs to volcanic action has been studied in the Yellowstone National Park and near Lassen Peak in California. Studies in recent years have been concerned with the source of the water as well as of its heat.

All the notable thermal springs in the eastern United States are in the Appalachian Highlands, principally in the region of folded rocks. The Atlantic Coastal Plain contains no appreciably warm springs. In Florida there are large springs whose water rises from a depth of a few hundred feet and is about 5° above the mean annual temperature, but they are not usually classed as thermal.

The only warm springs in the great Interior Plains region are at and near Hot Springs, S. Dak., in the vicinity of the Black Hills uplift of crystalline rocks. In the Interior Highlands thermal springs occur only in the Ozark region, the largest group being at Hot Springs, Ark.

The Rocky Mountain System includes the Yellowstone National Park, with its world-famous hot springs and geysers (see pls. 7, 12), and there are many other hot springs within this great mountainous region. In the Intermontane areas of great lava plains and faulted lava mountains in Utah, Nevada, southern Idaho, and eastern Oregon there are many hot springs, closely associated with the larger faults. In the Pacific Mountain System, including the Cascade Range and Sierra Nevada, there are many warm and hot springs, some of which issue in areas of granite, and others in areas of lava. In the Coast Ranges of California many thermal springs issue from different geologic formations.

Of the total of more than 1,000 thermal-spring localities listed in this paper more than half are situated in the three States of Idaho, California, and Nevada, each of which contains more than 150 thermal-spring localities. Wyoming, including the Yellowstone National Park, contains more than 100 hot-spring localities. Oregon, Utah, Colorado, Montana, and New Mexico contain several dozen thermal springs each, of which the principal ones are developed as resorts. The other thermal springs are scattered through 12 States, of which Massachusetts, New York, Pennsylvania, and North Carolina contain one spring or group each. More than half of the total number are developed as resorts or used for irrigation or water supply, but many have remained undeveloped because they are not easily accessible.

INTRODUCTION

Since the compilations and discussions of the thermal springs of the United States by Gilbert,[1] in 1875, and Peale,[2] in 1883, there has been no general publication on thermal springs for the United States as a whole, dealing with their geologic relations. A large amount of literature can be found, however, relating to individual thermal springs or to thermal springs in specific areas. The present paper is chiefly a compilation and summary of the available information on the thermal springs of the United States, but it also contains a large amount of original data obtained in the field by several geologists of the Geological Survey and by the United States Forest Service and the United States Indian Service. It summarizes the work that has previously been done, presents maps showing the location of the springs, tabulates the principal data, and includes a selected bibliography. An attempt has been made to present in very concise form as much information as possible regarding the geologic relations of the springs. Chemical analyses of the water are not included, but in the annotated bibliography publications that contain analyses of the water of the springs described are indicated.

For this report practically all the publications of the United States Geological Survey were searched for references to thermal springs. Considerable information on thermal springs is contained in geologic publications whose title and even index give no indication that such information is included. Considerable field work was done to interpret and supplement the published information. Some miscellaneous references have been used, but no attempt has been made to compile a complete or exhaustive bibliography. Such a bibliography would require a great amount of research and would probably be unsatisfactory because the mass of casual references would conceal the more significant ones. However, not all the references included here have equal relative value. Some writers discuss thermal springs in great detail, some dismiss them with slight mention, and others discuss them only in relation to ore deposits or with general reference to volcanology.

Some information has been obtained from field notes and unpublished memoranda of geologists of the United States Geological Survey, and the assembled data have been checked by several of these men. Acknowledgment in this respect is due especially to O. E. Meinzer, geologist in charge of the ground-water division of the United States Geological Survey, under whose direction the present report was prepared, and to Kirk Bryan, Clyde P. Ross, and Arthur M. Piper, who furnished information on several springs. Much of

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[1] Gilbert, G. K., U. S. Geog. and Geol. Surveys W. 100th Mer. Rept., vol. 3, pp. 17–155, 1875. (Map of hot springs of the United States, pl. 3; table of hot springs, pp. 150–153.)

[2] Peale, A. C., U. S. Geol. and Geog. Survey Terr. 12th Ann. Rept., for 1878, pt. 2, pp. 63–454, 1883. (Thermal springs of the United States, pp. 320–327; table of thermal springs, pp. 324–327.)

the information on thermal springs in the Western States was furnished by rangers of the United States Forest Service and by superintendents of the United States Indian Service. To all these men acknowledgment is due for their assistance in collecting the data.

Information on the springs was compiled, part of the text was written, and the bibliographic references were assembled by Norah D. Stearns in 1925–27. In later years the text was completed and many additions were made to the list of springs by Harold T. Stearns and Gerald A. Waring, and the annotated bibliography was prepared by Mr. Waring.

Most of the springs called "slightly thermal" in the literature, which have temperatures only a few degrees above the mean annual air temperatures of the localities where they issue, have been omitted from this report. In Gilbert's report he says: [3] "So far as temperatures are definitely known only these [springs] are included which exceed the mean annual temperature of the air by 15° F." In the present report some springs are included whose temperatures may not be more than 10° F. above the mean annual temperature of the locality where they issue; but the attempt has been made to include only such springs as are locally recognized to be appreciably warmer than normal. The approximate mean annual temperature for various parts of the United States is shown in figure 8.

In some areas of warm springs surface water seems to cause a cooling of the thermal water. In many places where a cool spring issues close to a warm one it is evident that the coolness is due to dilution of the thermal water by nonthermal water from local sources. In other places the association of warm and cool springs may be due to geologic structure, and the springs may have entirely different sources.

Such factors as inaccurate thermometers, lack of records of mean annual air temperature, and the vague definition or use of the term "warm" have led to the listing of a large number of thermal springs in early literature which are not now regarded as truly thermal.

LITERATURE OF THERMAL SPRINGS IN THE UNITED STATES

The earliest interest in thermal springs in the United States lay in their use as health resorts, and several books and articles dealing with this phase of the subject were published at an early date. Peale [4] summarized the history of these publications in 1894 as follows:

> Dr. John Bell was perhaps the first to write anything like a treatise on the mineral springs of the United States. In his Baths and Mineral Waters, published in 1831, part 2 is devoted to "a history of the chemical composition and medicinal properties of the chief mineral springs of the United States and Europe." He

[3] Gilbert, G. K., op. cit., p. 149.

[4] Peale, A. C., Natural mineral waters of the United States: U. S. Geol. Survey 14th Ann. Rept., pt. 2, p. 55, 1894.

enumerated 21 localities for the United States, which list was increased to 181 in The Mineral and Thermal Springs of the United States and Canada, which he published in 1855. Dr. J. J. Moorman, in his Mineral Springs of North America and How to Reach Them, published in 1873, refers to or describes 171 springs.

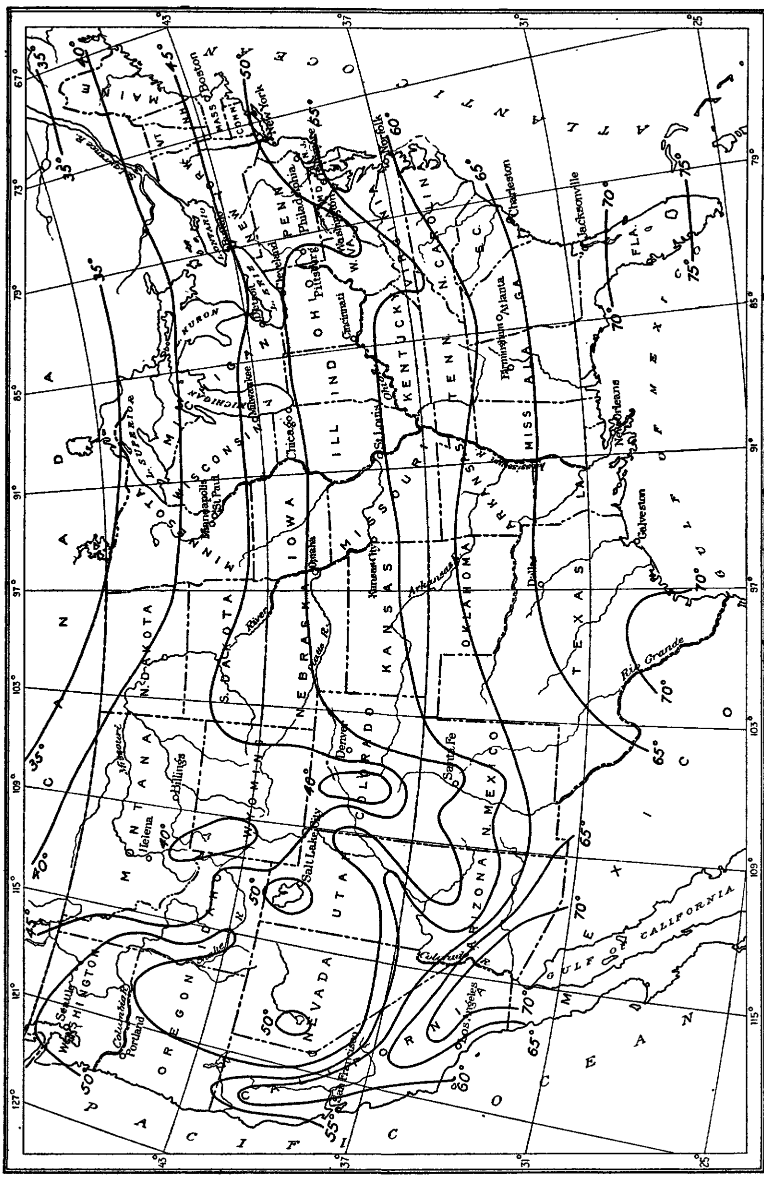

FIGURE 8.—Map of the United States, showing mean annual temperature. (From U. S. Weather Bureau.)

This was preceded by his Mineral Waters of the United States and Canada, published in 1867, and by several books relating to the Virginia springs, published in 1837, 1846, 1855, 1857, and 1859. Dr. George E. Walton's Mineral Springs of the United States and Canada, etc. (third edition), published in 1883, mentions for the United States 279 localities. Drs. William Pepper, H. I. Bowditch, A. N.

Bell, S. E. Chaillé, and Charles Dennison, as a committee of the American Medical Association, in 1880 made a very complete compilation, which included about 500 localities. Dr. A. N. Bell's Climatology and Mineral Waters of the United States, published during the latter part of 1885, enumerated 173 localities. Bulletin No. 32, published by the United States Geological Survey in 1886 (compiled by the writer), included 2,822 mineral-spring localities (and 8,843 individual springs), 634 of which were utilized as resorts and 223 as sources of commercial mineral water. One of the most recent enumerations is by Dr. Judson Daland in the list appended to Gould's New Medical Dictionary.

Many of the health resorts now most widely known and patronized are at thermal springs. The chemical analyses and temperature measurements contained in medical literature form an important contribution to geologic science. However, not all the analyses or even the temperature measurements have the same reliability. The value of such data depends largely upon the person making the analysis and taking the temperature.

The first contribution to the geologic study of thermal springs in the United States was probably that made by Rogers [5] in 1840–42. He briefly summarizes the studies of European writers, in which thermal springs are discussed in relation to geologic structure. He says, further:

> With the exception of brief and rather incidental notices published by myself and others, and the communications of Dr. Daubeny to Silliman's Journal and the Ashmolean Society, no account has yet been given of the peculiarities of geological structure associated with the thermal springs of the United States.

In 1876 Gilbert [6] compiled a table and map of the thermal springs of the United States. Many of the data were obtained from reports of the exploration parties in the little-known West and from the various books on mineral springs and health resorts of the better-known East. In his table Gilbert gives the location and temperature of each spring and a reference to the source of his information. His map is practically the only one of thermal springs in the United States published prior to the present report. It is of interest to note that the general distribution of thermal springs on plate 8 of the present report does not differ materially from that of Gilbert's map.

Peale's first publication on thermal springs appeared in 1883.[7] After an exhaustive description and discussion of the springs and geysers of the Yellowstone National Park (see pl. 12) he summarized the thermal springs and geysers of the world and then discussed "thermohydrology." A bibliography of the thermal springs and geysers of the United States and the world was included.

Three years later [8] Peale gave a table of mineral springs by States, showing the name and location, number, discharge, temperature,

[5] Rogers, W. B., On the connection of thermal springs in Virginia, with anticlinal axes and faults: Assoc. Am. Geologists Rept., pp. 323–347, 1843; republished in Geology of the Virginias, pp. 575–597, 1884.

[6] Gilbert, G. K., op. cit., pp. 150–153, pl. 3.

[7] Peale, A. C., U. S. Geol. and Geog. Survey Terr. 12th Ann. Rept., for 1878, pt. 2, pp. 63–454, 1883.

[8] Peale, A. C., Lists and analyses of the mineral springs of the United States: U. S. Geol. Survey Bull. 32, 1886.

character of water, and remarks regarding commercial sale or use as a resort. Analyses of many of the springs and a brief summary of the characteristics of the springs of each State were included. A large number of thermal springs were listed, but by far the greater number of the springs included are nonthermal.

In 1894 another report by Peale [9] discussed the history, origin, discharge, classification, and geographic distribution of mineral and thermal springs, the chemical composition and analyses of spring waters, and the utilization of mineral waters. A list of mineral-spring resorts was included.

More recently some compilations and discussions of the mineral and thermal springs of individual States have been published. Waring [10] discussed the mineral and thermal springs of California as related to geologic structure. As many of the springs, especially the thermal springs, issue at or near faults, a fault map of the State was included. A map showing the locations of the springs, detailed discussions of them, and tabulated data for each spring or spring group were also given.

In a similar report on the mineral springs of Alaska [11] geologic structure and relations were likewise assigned an important place. A map and a detailed discussion of the springs and localities were included. The thermal springs of Alaska and other Territories are not included in the present report, which treats only of the United States proper.

A report on the mineral waters of Colorado [12] dealt chiefly with the chemical features of mineral waters; but it also contained data on the general relation of mineral and thermal springs to geology. A description of the individual springs, or localities, included such facts as the location, discharge, temperature, use, and for some springs the kind of rock from which the water issues. The radioactivity of mineral waters was discussed by O. C. Lester.

In three papers published in 1905 and 1906 Lakes [13] gave a very good presentation of the geology of the hot springs of Colorado and the origin of their heat. These papers are of importance because they are among the few published articles that show geologic interest in thermal springs. In the geologic literature published since the time of Gilbert and Peale there are many references to and descriptions of thermal springs, but as a rule the springs are noted or described only in connection with areal geologic studies. The meager-

[9] Peale, A. C., Natural mineral waters of the United States: U. S. Geol. Survey 14th Ann. Rept., pt. 2, pp. 49–88, 1894.

[10] Waring, G. A., Springs of California: U. S. Geol. Survey Water-Supply Paper 338, 1915.

[11] Waring, G. A., Mineral springs of Alaska: U. S. Geol. Survey Water-Supply Paper 418, 1917.

[12] George, R. D., and others, The mineral waters of Colorado: Colorado Geol. Survey Bull. 11, 1920.

[13] Lakes, Arthur, Geology of the hot springs of Colorado and speculations as to their origin and heat: Colorado Sci. Soc. Proc., vol. 8, pp. 31–38, 1905; The hot and mineral springs of Routt County and Middle Park, Colo.: Min. Reporter, vol. 52, p. 438, 1905; Mineral and hot springs in Colorado: Min. World, vol. 24, pp. 359–360, 1906.

ness of geologic information regarding thermal springs is surprising; but even detailed studies of the geology of the springs do not always clearly show their origin.

Several writers who have published articles concerning thermal springs are economic geologists who are interested in them in relation to mineral deposits. Notable among these are Emmons, Lindgren, and Weed, who have studied present-day spring deposits for the light they shed on the processes and conditions of ancient spring deposits. Weed [14] says:

> The origin of metalliferous veins by hot waters ascending from great depths has always been a favorite theory with the practical miner, however widely the pendulum of geologic theory may swing away from this side of the arc of thought. Nevertheless, although hot springs are of as world-wide occurrence as ore deposits, examples of ore deposition by hot springs are rare. Indeed, the only examples generally recognized are the familiar ones at Steamboat Springs, Nev., and Sulphur Bank, Calif., though the fact that hot waters can dissolve the metals and form ores is established by the observations of Daubrée.

He then discusses the formation of mineral veins in connection with hot springs at Boulder, Mont.

Another group of students of thermal springs are the volcanologists, who are interested chiefly in the relations of thermal springs to problems of volcanic action. Day and Allen studied the hot springs of Lassen Volcanic National Park in relation to the volcanic activity of Lassen Peak,[15] and also The Geysers, in Sonoma County, Calif.[16] Daly [17] discussed the thermal springs of Yellowstone Park in relation to former volcanic activity. Interest in the magmatic and meteoric origins of thermal waters and the relation of the springs to volcanism has been expressed in a symposium on hot springs.[18]

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[14] Weed, W. H., Mineral vein formation at Boulder Hot Springs, Mont.: U. S. Geol. Survey 21st Ann. Rept., pt. 2, p. 233, 1900.

[15] Day, A. L., and Allen, E. T., The volcanic activity and hot springs of Lassen Peak: Carnegie Inst. Washington Pub. 360, 1925.

[16] Allen, E. T., and Day, A. L., Steam wells and other thermal activity at "The Geysers", Calif.: Carnegie Inst. Washington Pub. 378, 1927.

[17] Daly, R. A., The nature of volcanic action: Am. Acad. Arts and Sci. Proc., vol. 47, pp. 47-122, 1911.

[18] The temperatures of hot springs and the sources of their heat and water supply: Jour. Geology, vol. 32, pp. 177-225, 291-310, 373-399, 449-471, 1924. This symposium consists of the following papers:

Day, A. L., and Allen, E. T., The sources of the heat and the sources of water in the hot springs of the Lassen National Park, pp. 177-190.

Adams, L. H., A physical source of heat in springs, pp. 191-194.

Van Orstrand, C. E., Temperatures in some springs and geysers in Yellowstone National Park, pp. 194-225.

Morey, G. W., Relation of crystallization to the water content and vapor pressure of water in a cooling magma, pp. 291-295.

Meinzer, O. E., Origin of the thermal springs of Nevada, Utah, and southern Idaho, pp. 295-303.

Zeis, E. G., Hot springs of the Valley of Ten Thousand Smokes, pp. 303-310.

Watson, T. L., Thermal springs of the southeast Atlantic States, pp. 373-384.

Brown, J. S., The hot springs of the Republic of Haiti, pp. 384-399.

Bryan, Kirk, The hot springs of Arkansas, pp. 449-459.

Day, A. L., Hot springs and fumaroles of "The Geysers" region, California, pp. 459-460.

Washington, H. S., Notes on the solfatara of Sousaki (Greece), a recent eruption of Methana (Greece), and recent maccalube at Vulcano, pp. 460-462.

Wright, F. E., The hot springs of Iceland, pp. 462-464.

Sosman, R. B., Notes on the discussion of the papers presented in the symposium on hot springs, pp. 464-468; General summary of the symposium on hot springs, pp. 468-471.

Since this paper was transmitted by the authors, a comprehensive report by Allen and Day on the results of their intensive investigations in Yellowstone National Park has been published.[19]

GEOLOGIC PROBLEMS RELATING TO THERMAL SPRINGS

SOURCES OF THE WATER

There are two main phases of the problem of the origin of thermal springs, namely, the sources of the water and the sources of the heat. The water may be meteoric—that is, surface water which has percolated downward, been heated, and then ascended to the surface; it may be juvenile—that is, a product from the magma itself which has reached the surface for the first time; or it may be a mixture of meteoric and juvenile waters in any proportion.

Clarke [20] says:

> Until quite recently the prevalent opinion has been that all spring waters, including those emitted by geysers, were originally meteoric. Modern investigations into volcanism and upon the subject of metalliferous veins have, however, led to a reopening of the question. E. Suess, speaking with especial reference to the thermal springs of Carlsbad, has advanced strong arguments to show that waters of this class are "juvenile" and now see the light of day for the first time; that is, they issue from deep within the earth, from the fundamental magma itself, and bring up veritable additions to the hydrosphere. * * *
>
> This subdivision of springs into vadose, or those which represent original infiltration of surface waters, and juvenile, as Suess terms them, has had wide but not universal acceptance. A difficulty in applying the proposed nomenclature arises from the fact that it is not easy to determine where a given water belongs. Armand Gautier, however, has pointed out several criteria which may make discrimination possible. He shows that vadose waters, or waters of infiltration, are characterized by fluctuations in composition, concentration, and rate of flow, depending upon local and variable conditions, such as abundant rain or drought. They also contain, as a rule, carbonates of lime or magnesia, chlorides, or sulphates. Virgin or juvenile waters, on the contrary, are fairly constant in all essential particulars and carry sodium bicarbonate, alkaline silicates, heavy metals, etc., as chief constituents, with chlorides or sulphates only as accessories, and practically no carbonates of the alkaline earths. The vadose waters, moreover, issue from faults having no relation to the metallic veins of the surrounding territory—a lack of relation which is conspicuous as regards juvenile springs. Gautier holds that hydrogen emitted from the hot interior of the earth acts as a reducing agent upon metallic oxides and so forms the magmatic waters of the springs. With the waters thus generated, other water, that of constitution from minerals like the micas, is commingled.

Regarding the radioactivity of spring waters as a criterion he says:[21]

> A very large number of such waters possess this property, but no distinction between vadose and juvenile waters can be based upon the observations. Waters of both classes are radioactive, but the phenomenon is perhaps most common among waters of volcanic origin, or at least among thermal springs.

[19] Allen, E. T., and Day, A. L., Hot springs of the Yellowstone National Park (microscopic examinations by H. E. Merwin): Carnegie Inst. Washington Pub. 466, 1935.

[20] Clarke, F. W., The data of geochemistry, 5th ed.: U. S. Geol. Survey Bull. 770, pp. 213–214, 1924.

[21] Idem, pp. 215–216.

Hague [22] concluded that the waters of the hot springs and geysers of the Yellowstone National Park are essentially meteoric waters that have penetrated downward a sufficient distance to attain an increased temperature and have been forced to the surface again by ascending currents. The geologic evidence on which he based his conclusion consists of "the nature and structure of the rocks through which the heated waters reach the surface, the mineral constituents contained in the waters, the composition of the associated gases, and the characters of the varied sediments and incrustations deposited around the springs and pools."

Day and Allen [23] concluded that the hot springs of Lassen Volcanic National Park are fed chiefly by surface water that drains the basins in which they lie, but that a probably smaller portion of the water is derived from an underlying magma or batholith. The local and seasonal variations in the volume of the surface water account for the variations in volume and for the greater part of the variations in temperature in the springs. In their detailed report on the area they say: [24]

> Altogether the evidence for the surface origin of water in the Lassen springs is so convincing to an observer that if the hypothesis of juvenile or magmatic water had never been proposed the entire adequacy of the simpler theory to account for all the water would probably never have been questioned.

The magmatic water rises in the form of steam along with other volcanic gases through clefts in the rock, is condensed by the ground water, and becomes mingled with it. These conclusions were confirmed by the later work of Allen and Day in Yellowstone National Park.

Much of the information presented in the symposium on thermal springs already cited supports the conclusion that at least part of the water of many thermal springs is of magmatic origin. Morey [25] showed that the amount of water that may be dissolved in a batholithic magma, of the chemical character described by him, may be sufficient to supply small hot springs for hundreds of thousands of years without any addition of surface water. He also showed that the conditions of crystallization of such a magma may yield water vapor under considerable pressure.

It should not be inferred from the preceding discussion that the proportion of magmatic water in the discharge of thermal springs is large. In many places large bodies of hot rock lie at shallow depths

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[22] Hague, Arnold, Origin of the thermal waters in the Yellowstone National Park: Geol. Soc. America Bull., vol. 22, pp. 103–122, 1911.

[23] Day, A. L., and Allen, E. T., The sources of the heat and the source of water in the hot springs of the Lassen National Park: Jour. Geology, vol. 32, pp. 178–190, 1924.

[24] Day, A. L., and Allen, E. T., The volcanic activity and hot springs of Lassen Peak: Carnegie Inst. Washington Pub. 360, p. 162, 1925.

[25] Morey, G. W., Relation of crystallization to the water content and vapor pressure of water in a cooling magma: Jour. Geology, vol. 32, pp. 291–295, 1924.

but do not give off appreciable quantities of magmatic water. For example, the amount of steam given off by a body of hot rock at shallow depth at Kilauea Volcano, Hawaii, is negligible except immediately after rains. At Klamath Falls, Oreg., it is a common practice to drill shallow holes to the hot rock and insert coils through which water is circulated for heating. These holes do not steam, and yet surface water introduced into them is promptly heated and returned by convection to the surface. The major part of the discharge of the hot springs near Klamath Falls is doubtless meteoric water circulating through cracks in a similar way.

SOURCES OF THE HEAT

The heat of thermal springs may be derived (*a*) from the natural increase in temperature of the earth with depth, (*b*) from an underlying body of hot or possibly molten rock, (*c*) from zones where there has been faulting of the rocks with resultant development of heat, (*d*) from chemical reactions beneath the surface, or (*e*) from the energy derived by the disintegration of radioactive elements.

In most areas where the rocks have been little disturbed the records obtained from deep wells and mine shafts show that the temperature increases 1° F. for about each 40 to 90 feet increase in depth. Hence, surface water that penetrates to a depth of 1,000 feet may have its temperature increased perhaps 20°; and if it rises fairly rapidly to the surface again, it may issue at a temperature noticeably higher than normal. Such a condition is believed by Reeves [26] to account for the warm temperature of certain springs in Virginia.

The warmth of most deep-well waters is due to this natural increase of temperature of the earth with depth. Many springs, known as artesian springs, discharge water warmed by contact with warm rocks at the depth to which the water has penetrated.

Lava that has not yet cooled to normal surface temperature may underlie areas of volcanic rocks at moderate depths. Magmas may underlie some areas at great depth and transmit the heat to the overlying materials. Meteoric water that in such areas penetrates near the heated materials may be thus heated.

In areas of present or very recent volcanic activity the source of heat of the hot springs is obviously the uncooled lava below the surface of the earth. In Lassen Volcanic National Park, Calif., the thermal springs are probably associated with the volcanic activity of Lassen Peak. Similarly in the Valley of Ten Thousand Smokes, in Alaska, the hot springs are related to the activity of Katmai Volcano. Most of the hot springs of Iceland, Java, Japan, New

[26] Reeves, Frank, Thermal springs of Virginia: Virginia Geol. Survey Bull. 36, p. 28, 1932.

Zealand, and other volcanic regions are likewise related to the volcanic activity.

Hot igneous rocks that now lie at a moderate depth below the surface may be a source of heat for thermal springs, both from heat radiated by the rocks and from steam given off, which mingles with and heats meteoric water that has penetrated downward. The courses by which the heated water returns to the surface, through ascending hydraulic and convection currents, depend on the local geologic structure. The temperatures of the springs at the surface will depend upon the initial heat of the water, the loss of heat as the water rises, and the admixture of cool ground water.

It is stated by Daly [27] that in the Yellowstone National Park the rhyolite probably passes downward into a typical granite batholith and that this batholith is relatively near the surface and is the source of heat for the geysers and hot springs.

Much heat is generated by crushing and shearing that accompany the movement of large bodies of rock. This heat is probably the source of the heat of some thermal springs. It is difficult, however, to determine whether the heat of the thermal water is due to the heat of metamorphism or to the fact that faulting and shearing allow the upward escape of heated water from considerable depths.

Chemical reaction as a source of heat for thermal springs has been much discussed. Some chemical reactions generate heat, but it seems doubtful whether the heat thus generated is sufficient in quantity for any extensive thermal action. Day and Allen [28] concluded that chemical oxidation is in all probability a minor factor in the heat supply.

In addition to the four principal sources of heat just described, several minor conditions may be contributing factors in some springs. Radioactivity as a source of heat for thermal springs has been considered by many authorities. Schlundt and Moore [29] found that the rhyolites, limestones, thermal waters, gases, and sediments of the Yellowstone National Park are all radioactive. They say:

> These data certainly seem to indicate that the hydrothermal activity so manifest in the park is not connected with localized deposits of radium. In the above calculations the question of heat lost by diffusion and other factors is not taken into consideration, but after allowing a generous margin for error we do not see how more than 1 percent of the heat required for the hydrothermal action can be ascribed to the radium content of the rock.

[27] Daly, R. A., The nature of volcanic action: Am. Acad. Arts Sci. Proc., vol. 47, pp. 63-67, 1911.

[28] Day, A. L., and Allen, E. T., The sources of the heat and the source of water in the hot springs of the Lassen National Park: Jour. Geology, vol. 32, p. 183, 1924.

[29] Schlundt, Herman, and Moore, R. B., The radioactivity of the thermal waters of the Yellowstone National Park: U. S. Geol. Survey Bull. 395, p. 35, 1909.

Regarding radioactivity as a source of heat in the Lassen Peak area, Day and Allen[30] say:

While the radioactivity of the gases and waters of the Lassen springs has not been investigated, tests of this kind have been made in Iceland by Thorkelsson and in the Yellowstone Park by Schlundt and Moore, with decisive results. The amount of the emanation in both these famous hot-spring localities is considerable, but no connection was found between the amount of it and the temperature of the waters. In fact, the cold waters of the Yellowstone were slightly more radioactive on the average than the hot waters. In both localities the investigators were satisfied that radioactivity had nothing to do with the source of the heat. It is also noteworthy that mineral deposits which are most radioactive are not found associated with local high temperatures, and we conclude that further developments of importance along this line are unlikely.

In the discussion of radioactivity of the mineral waters of Colorado, Lester [31] states:

A careful comparison of the radioactivity measurements with the data obtained from the chemical analyses shows that there is no connection between radioactivity and any chemical property. Neither is there any connection between activity and temperature nor between the activity in water or gas and that in the deposits. Some springs situated near each other have shown activities of very different magnitude, and again the individual springs of a closely associated group have shown quite similar activities. In the first case the waters of the separate springs usually had the appearance of being different in character, but not always.

Adams [32] has discussed as a physical source of heat in springs the effects accompanying release of pressure, or porous-plug expansion. He shows that the forced flow of a fluid from a high pressure to a low pressure through a porous plug may develop considerable heat. For liquids there may result an increase in temperature of as much as 20° C. (36° F.) for a fall in pressure of 1,000 atmospheres. It is said that this process will always be operative to some extent where water is flowing. It may account for part of the rise in temperature of such springs as those in Virginia and Georgia, although probably it is not quantitatively important in these springs.

An interesting local cause of heat in thermal springs is mentioned by Daubeny,[33] who quotes Kastner as stating that in the Westerwald, in Prussia, the burning of brown coal underground has caused so much heat in the contiguous rocks as to give rise to several warm springs.

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[30] Day, A. L., and Allen, E. T., op. cit. (Jour. Geology, vol. 32), p. 180.

[31] Lester, O. C., George, R. D., and others in, Mineral waters of Colorado: Colorado Geol. Survey Bull. 11, p. 188, 1920.

[32] Adams, L. H., A physical source of heat in springs: Jour. Geology, vol. 32, pp. 191–194, 1924.

[33] Daubeny, Charles, Report on the present state of our knowledge with respect to mineral and thermal waters: British Assoc. Adv. Sci. Rep. 5th meeting, vol. 5, p. 67, 1837.

RELATION OF THERMAL SPRINGS TO GEOLOGIC STRUCTURE

An important phase of the problems dealing with thermal springs relates to the manner of transfer of the heated water to the surface and, in the springs of meteoric origin, the transfer of the cool meteoric water down to the region where the heating occurs.

In areas of volcanic activity where the warm rocks lie at or near the surface, there is no difficulty in explaining how meteoric water may reach the source of heat, or how either meteoric or magmatic water may come to the surface. The heat is near the surface and may be in the zone of ground-water circulation, and the volcanic vents and fissures give ample openings for ejection. The thermal springs of the Lassen Volcanic National Park and the Valley of Ten Thousand Smokes are illustrative of this condition.

When the magma is at moderate depths in the earth, water probably ascends from it to the surface through fissures and faults. Ground-water circulation often occurs at moderate depths over wide areas, and the presence of a magma below the surface can easily account for thermal springs in specific regions. The water of such springs may be meteoric or magmatic, or a mixture of the two. If the magma is at a considerable depth below the surface, the meteoric water cannot readily reach it or the associated hot rocks unless there are favorable structural conditions; below certain depths fissures are narrow rather than wide, because of the great pressure of the overlying rocks. However, magmatic steam under high pressure can probably penetrate tight faults and fractures.

The position of many thermal springs is definitely related to the geologic structure. A large number issue along major fault zones. This is true of many thermal springs in the regions of faulted mountain blocks in Utah, Nevada, California, and Oregon. Other thermal springs issue along anticlinal axes where minor fractures facilitate the escape of heated water. In some places, as in Virginia, synclinal structure produces artesian conditions that carry ground water to depths where it becomes heated, and thence to the surface.

Meinzer [34] says:

It is generally believed that thermal springs which do not issue directly from hot volcanic rocks owe their high temperatures to artesian structure that causes the ground water to descend to great depths. However, most of the thermal springs in Nevada, Utah, and southern Idaho do not issue from rocks that have definite artesian structure, and some issue from granite that almost certainly has no artesian structure. In the Goose Creek Basin the Tertiary beds form an artesian system that yields warm water, but the artesian structure apparently has nothing to do with the rise of the warm water through the underlying older rocks. Moreover, most of the warm water issues directly from the older rocks, which are so much broken and deformed that they seem to lack entirely the

[34] Meinzer, O. E., Origin of the thermal springs of Nevada, Utah, and southern Idaho: Jour. Geology, vol. 32, pp. 299–300, 1924.

structure of an artesian basin. Another typical example of the lack of artesian conditions is afforded by the Darrough Hot Springs in Big Smoky Valley, Nev. These springs are on an alluvial fan on the west side of the valley and issue from bouldery valley fill, but their water doubtless comes from the underlying rock. The mountains on both sides of the valley are composed mainly of greatly deformed Paleozoic quartzite, limestone, slate, and schist and rather old Tertiary rhyolite and tuff. The mountain front on the west side of the valley is essentially a fault scarp produced by extensive faulting in Pliocene and Quaternary time. Obviously such a structure would be considered entirely unfavorable for artesian water.

AGE OF THERMAL SPRINGS

In many areas thermal-spring activity has apparently been going on for a long time. Some of the thermal springs that issue along faults have probably been discharging since the time when the faulting took place. The springs on the lower limbs of synclines have presumably existed since the present land forms were produced. Thus it appears probable that some of the present thermal springs or spring localities have been active since the beginning of the Quaternary period. In some places there are extensive deposits of calcareous tufa or siliceous sinter near hot springs. These deposits mark a long period of deposition and usually show minor changes in the position of the springs, as streams have cut down or other agencies have slowly affected the points of discharge of the water. On the other hand, permeable volcanic rocks may have such a vigorous circulation of ground water that their heat is soon dissipated, and hence their thermal springs are of relatively short duration.

THE SPRINGS, BY PHYSIOGRAPHIC DIVISIONS

DISTRIBUTION

Gilbert [35] discussed the distribution of the thermal springs in the United States in relation to the rock deformation and the volcanic eruptions, making the following statements:

In the region of the Appalachians the phenomena of eruption have always been subordinate to those of corrugation, and they appear to be in no wise connected with thermal springs. In the western region eruption has been nearly as universal as corrugation and in places rivals it in the magnitude of its movements.

In examining the map the first thing to note is that the Mississippi region contains no hot springs nor does the plain of the Atlantic coast. The single locality in Arkansas is referable to the Archean Ozark corrugation. In the Colorado Plateau but five localities are noted, a number decidedly below the mean of the western mountain region, which, for the same area, averages 13 localities. It is true that it [the plateau] is not yet fully explored, but it is nevertheless probable that the record of its hot springs is nearer complete than that of the mountain region. The distribution of hot springs is thus shown to coincide very exactly

[35] Gilbert, G. K., U. S. Geog. and Geol. Surveys W. 100th Mer. Rept., vol. 3, pp. 147–149, pl. 3, 1875.

with that of corrugation, there being none in undisturbed regions and few in regions of little disturbance.

Further, he showed that the range of temperature is far higher in the western region than in the eastern, and also the number of localities is far greater. He said in explanation:

> The geological relations appear to accord with this hydrothermal contrast. The corrugation and the eruption of the Appalachian region are things of the past, not known to have continued so late as Cretaceous time; while in the West these actions have persisted to so late a period that we have good reason to believe they have not ceased. It is dangerous to argue from single coincidences, but certainly, so far as these facts go, they tend to confirm the explanations of the phenomena that have grown out of the theories of mountain building. We may consider the heat of springs in the Appalachians due entirely, as argued by Rogers, to the normal—we might almost say static—downward increase of temperature, brought to bear by the means of deep-seated watercourses, following faults and curved strata. In the western mountain region a greater heat is obtained by the same means, because of local upraisings of the geoisothermal planes, produced by the progressive corrugation, and the intensity of the phenomena is further heightened by the intrusion and extrusion of lavas.

Gilbert found it difficult with the meager data available to compare different portions of the western province. He assigned the sparseness of thermal springs in some regions to inequality of observation but recognized that there are several areas of few or no thermal springs which needed explanation. He stated that he was at a loss for the interpretation of some of these blank areas.

The United States has been divided into eight main physiographic or geomorphic regions,[36] each with distinctive geologic structure. These main divisions are the Laurentian Upland, Atlantic Plain, Appalachian Highlands, Interior Plains, Interior Highlands, Rocky Mountain System, Intermontane Plateaus, and Pacific Mountain System (pl. 8). As the thermal springs are closely related to the geology, they may be fittingly discussed according to these physiographic divisions. In the following discussion the publications of Bowman[37] and Lobeck[38] have been followed with respect to physiography.

LAURENTIAN UPLAND

That part of the Laurentian Upland which lies within the United States includes only northwestern Michigan, northern Wisconsin, and northeastern Minnesota. It is a peneplain that has been considerably dissected and glaciated. It is composed of crystalline rocks of complex geologic structure, overlain by glacial drift. No thermal springs are known in this division in the United States, even where the bedrock is not covered with drift.

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[36] Fenneman, N. M., Physiographic divisions of the United States: Assoc. Am. Geographers Annals, vol., 6, pp. 19–98, 1916.

[37] Bowman, Isaiah, Forest physiography, New York, 1911.

[38] Lobeck, A. K., Physiographic diagram of the United States, 1922.

ATLANTIC PLAIN

The Atlantic Plain includes the Coastal Plain area extending south from Long Island to Florida and west from Florida through southern Texas to Mexico. This division comprises chiefly lowlands underlain by sand, silt, and clay, of Cretaceous, Tertiary, and Quaternary age, in strata that incline gently seaward. In these soft beds there are many springs, some of which have large flow, but no truly thermal springs are known. In Florida there are several springs that are veritable rivers in size. Their source is in shallow water-bearing beds under artesian pressure, and the water is a few degrees warmer than that of ordinary surface springs. In some early reports these large springs were classed as thermal. McGee [39] mentioned "the deep-seated springs of Florida, of which most are thermal." Meinzer,[40] however, has listed the large springs of Florida and gives their temperatures as ranging from 70° to 78°. As this is hardly 5° above the mean annual temperature of the State, they are not thermal springs in the ordinary use of the term and therefore are not listed in the present report.

Raleigh Mineral Spring, 10 miles north of Memphis, Tenn., in the northern part of the Mississippi embayment, is listed in some early records as thermal. It was formerly developed as a hotel resort but in late years has been used only as a local water supply. In 1934 the temperature of its water was only 60°, which is practically the mean annual temperature of the locality.

APPALACHIAN HIGHLANDS

The Appalachian Highlands comprise a series of plateaus and mountains in which the rocks have been greatly deformed. All the distinctly thermal springs in the eastern part of the United States are in this region.

The northernmost warm spring that is known is Sand Spring, near the northwest corner of Massachusetts. (See pl. 8.) Its water has a temperature of 76°, which is about 30° above that of the shallow well waters, and its discharge is 400 gallons a minute. This large spring has been used since early colonial times, and for the last 30 years or more the water has been used commercially in the manufacture of carbonated beverages.

About 20 miles to the south, in New York, is Lebanon Spring. It has a temperature nearly the same as Sand Spring and a somewhat greater discharge. It was developed as a bathing resort in early colonial days and is still a noted resort. Both of these springs are near the north end of the Appalachian Highlands and issue from

[39] McGee, W J, Potable waters of the eastern United States: U. S. Geol. Survey 14th Ann. Rept., pt. 2, p. 44, 1894.

[40] Meinzer, O. E., Large springs in the United States: U. S. Geol. Survey Water-Supply Paper 557, p. 11, 1927.

Cambrian rocks, in an area where there has been intense folding and much faulting. The water of both springs is probably of surface origin, but it has penetrated to considerable depth and has returned to the surface along fractures. It is only moderately mineralized.

In an early report of the Geological Survey of Vermont mention was made of a slightly warm spring at Bennington.[41] Later reports do not list this spring, however, and information obtained in 1934 indicates that the reference was to Morgan Spring, near the center of the city, whose temperature is about 53°, or only 8° above the mean annual temperature. Although the water may have a fairly deep source, similar to that of Sand Spring and Lebanon Spring, not far to the south, it is not included among the thermal springs in this report.

Fully 200 miles southwest of Lebanon Spring and about 15 miles northwest of Harrisburg, Pa., is the Perry County Warm Spring. It was early developed as a bathing resort, but in recent years it has not been so used. It has a temperature of 72° and a discharge of 90 gallons a minute. The temperature indicates that the water rises from a considerable depth.

The principal group of thermal springs in the Appalachian Highlands is in Virginia and West Virginia. These springs are discussed by Watson [42] as follows:

The thermal springs of Virginia are the best known and have been the longest studied in the southeast Atlantic States. The contributions by Prof. William Barton Rogers on these are the most important. Although Professor Rogers listed more than a score of thermal springs in Virginia, including several in West Virginia, giving temperature and other data on each, the thermal springs of the Warm Spring Valley, including the Hot, Warm, and Healing Springs in Bath County, have the highest temperatures and are best known. The temperature of most of the others is only a few degrees above the annual atmospheric mean.

All the Virginia thermal springs are located in the folded Appalachians west of the Blue Ridge. The waters issue through Paleozoic sedimentary rocks, all of which have been strongly folded and in places profoundly faulted. Igneous rocks, both acidic and basic, cut the Paleozoic sedimentary rocks in places, chiefly as dikes. They occur some distance from the springs, are not later than Triassic in age, are entirely cold, and have no relation to the thermal waters.

The linear grouping of the springs has long been recognized, and Professor Rogers early showed that the more decided thermal springs issue along or near lines of anticlinal axes. They are regarded as due to fractures or zones of crushing which may not always be visible at the surface. Those of the Warm Spring Valley rise along the west limb of the fold through steeply dipping nearly vertical beds of Cambro-Ordovician limestones.

Warm Spring Valley has resulted from deep erosion of the crust of Warm Springs Mountain, a conspicuous anticline of the Appalachian type, composed of Silurian sandstone or quartzites and shales overlying Cambro-Ordovician limestones. Steep dips, nearly vertical in places, characterize the west limb. Structure sections (fig. 9) through Warm Spring Valley near the Hot and Warm

[41] Adams, C. B., Vermont Geol. Survey 2d Ann. Rept., p. 250, 1846.

[42] Watson, T. L., Thermal springs of the southeast Atlantic States: Jour. Geology, vol. 32, pp. 376–378, 1924.

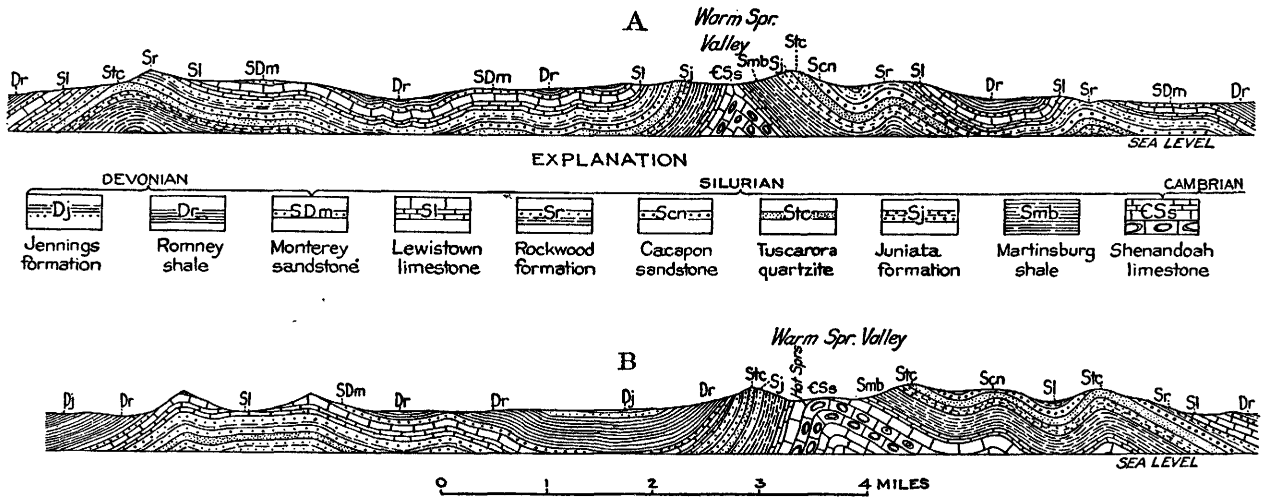
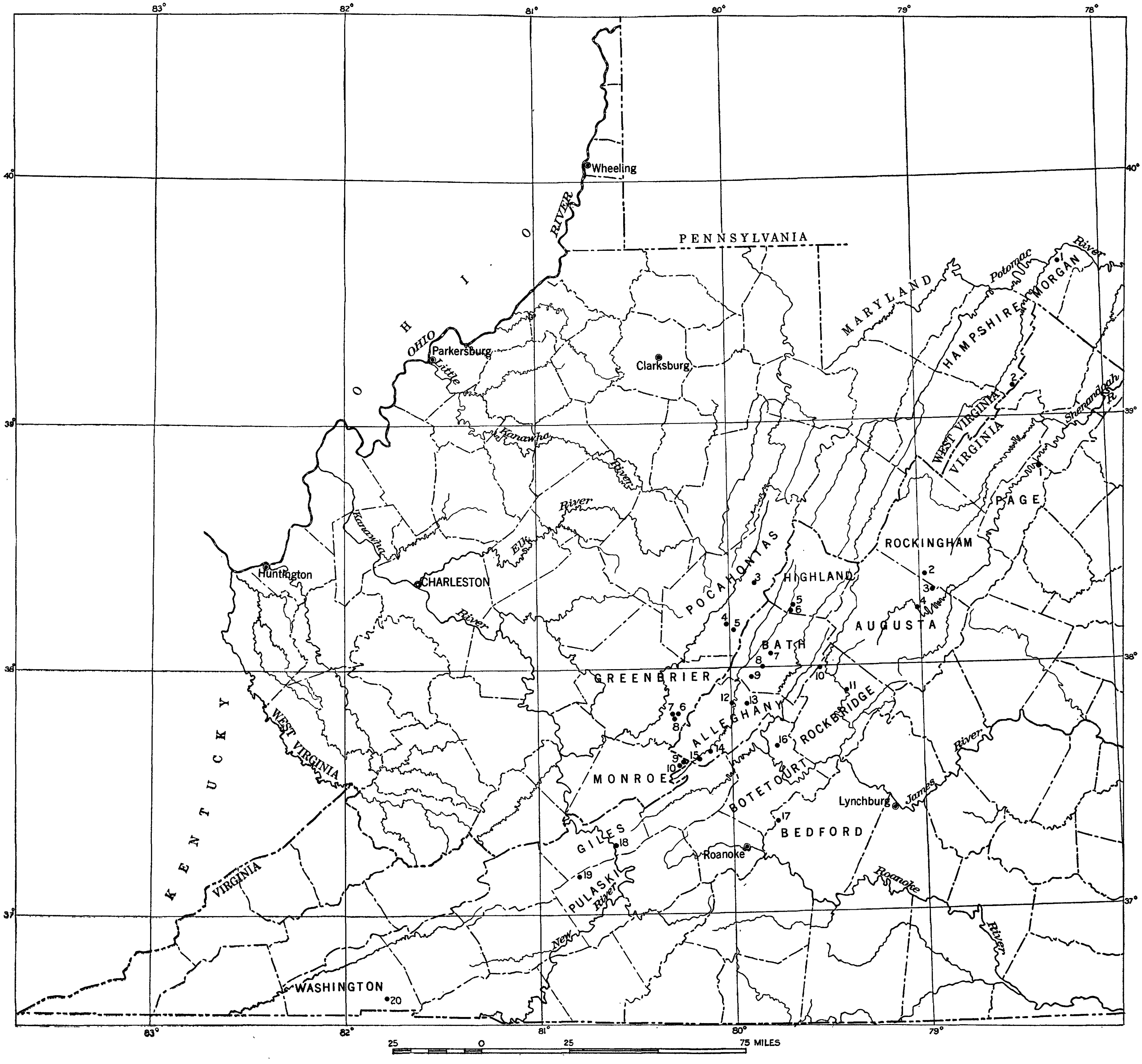
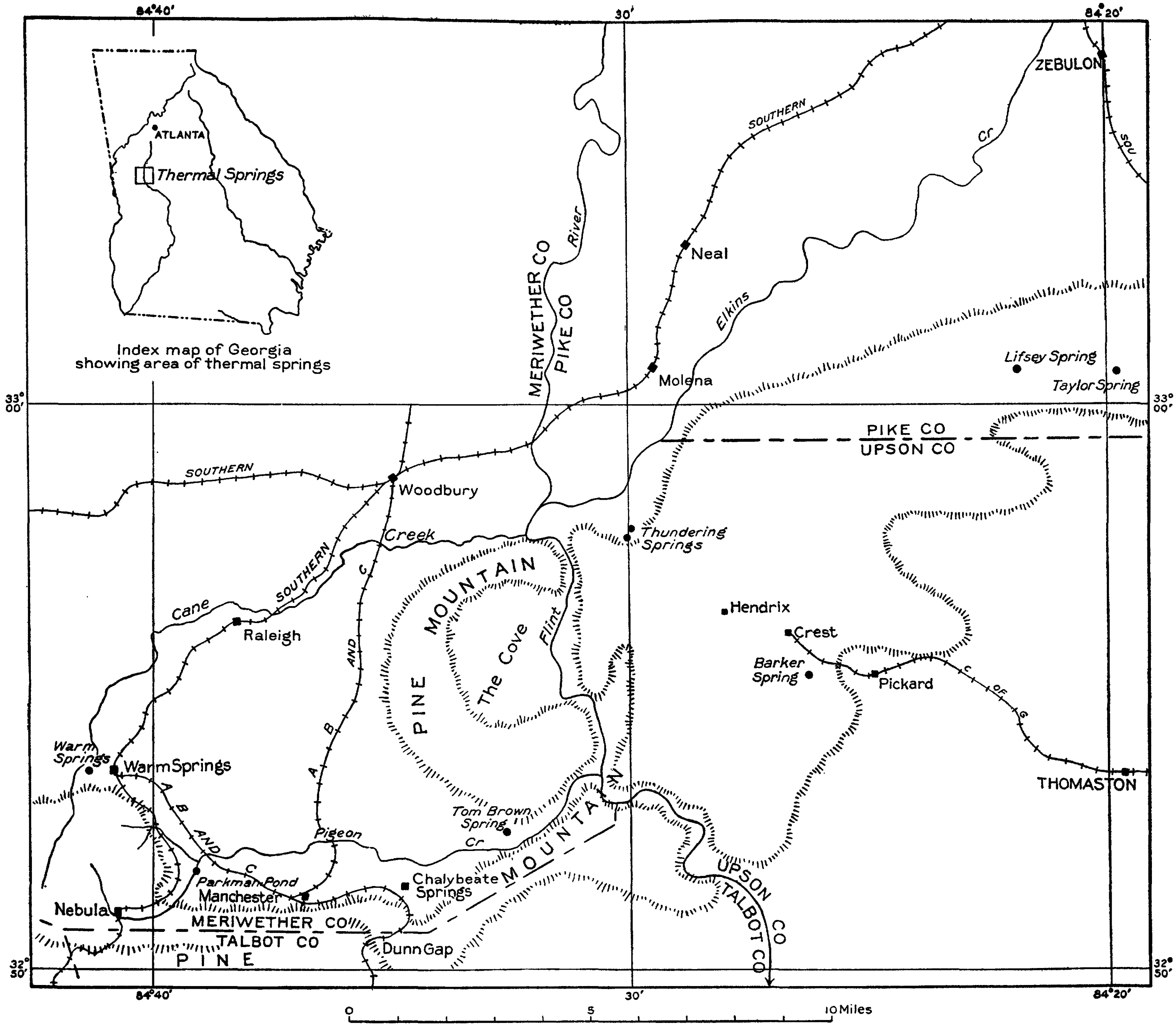


FIGURE 9.—Geologic cross sections showing general structure at thermal springs in the Virginia region. A, Section along a line a short distance north of Warm Springs, Bath County; B, section along a line 3½ miles farther south and a short distance north of Hot Springs. (From Watson (Jour. Geology, vol. 32, p. 377, 1924), after Darton.)



MAP OF VIRGINIA AND WEST VIRGINIA SHOWING THERMAL SPRINGS.

Numbers refer to table in text.



MAP OF PART OF GEORGIA SHOWING THERMAL SPRINGS AND THEIR RELATION TO PINE MOUNTAIN.

Springs generalize the structural relations of the rocks. The sections, adopted from Darton, show the regular succession of formations and the absence of faulting, although faults may and probably do occur. The waters rise to the surface along fracture or slip planes in the limestone.

In 1927–29 the thermal springs of the Virginia region were studied by Reeves,[43] who concluded that

The springs are produced by meteoric waters entering a permeable bed along its outcrop at a relatively high altitude on the crest or limb of one anticline and rising to the surface where the same bed crops out at a lower altitude in another anticline, the temperature of the waters being an expression of the normal earth temperature in the deep synclinal basins through which the water circulates.

Of the 321 springs examined by Reeves, 45 had temperatures between 55° and 59.5°, and 40 had temperatures between 60° and 105.8°. Although nearly all these springs are similar in character and in their relation to the structure, their temperatures grade insensibly from cool to warm, and only an arbitrary division can be made; but as the mean annual temperature of the district is 50° to 55°, only the 20 springs in Virginia and 10 in West Virginia that have temperatures appreciably above 60° are indicated on plate 9 and included in the tabulated list of the present report as being distinctly thermal. This number includes several springs mentioned by Reeves but not listed in his report.

In an early report by Peale[44] a warm spring on the French Broad River near the east border of Tennessee was listed, but inquiry in 1934 failed to verify this report. The thermal springs at Hot Springs, N. C., are about 3 miles east of the Tennessee border. These were early developed as a resort.[45]

In 1933 a detailed study of geologic conditions near Warm Springs, Ga., was undertaken by the United States Geological Survey. In addition to the three well-known thermal springs of the district, five others were found to have temperatures noticeably above normal. There may be a few other small springs of warm water along the north side of Pine Mountain. The positions of the known thermal springs with relation to the mountain are shown in plate 10.

INTERIOR PLAINS

The Interior Plains cover practically all the lowland area between the Appalachian region and the Rocky Mountains and contain nearly one-half of the area of the United States. In the Black Hills of South Dakota there are three hot-spring localities, the principal one at Hot Springs and the others 3 miles to the west and 10 miles to the south-

[43] Reeves, Frank, Thermal springs of Virginia: Virginia Geol. Survey Bull. 36, p. 28, 1932.

[44] Peale, A. C., U. S. Geol. and Geog. Survey Terr. 12th Ann. Rept., pt. 2, p. 324, 1883 (table of thermal springs in the United States).

[45] Idem. Gilbert, G. K., U. S. Geog. and Geol. Surveys W. 100th Mer. Final Rept., vol. 3, p. 150, 1875 (table of thermal springs in the United States).

west (pl. 8). These seem to be related to the Black Hills uplift. The thermal springs and their geology have been described by Darton.[46] The warm water issues from crevices in the Minnekahta limestone and is believed to rise from the Deadwood formation, which is about 1,000 feet below the surface. The water is nearly 50° warmer than the mean annual temperature. The upward escape of the water has apparently been facilitated by fracturing. The springs at Hot Springs were early developed as a resort, and a United States soldiers' home has been established there. The mineral content of the water is similar to that of artesian wells of the district.

Throughout the rest of the great region of the Interior Plains no definitely thermal springs are known. In western Kentucky, Grayson Springs, in Grayson County, and Linsey's Mineral Spring, in Christian County, were listed by Peale [47] as thermal. These places were early developed as resorts but have not been so used for a number of years. The early reported temperatures of their waters (58° to 71°) could not be verified in 1934. It seems doubtful whether they are appreciably above the normal for springs of the district, and they have not been included in the present tabulation.

In the report on a part of northern Texas, Gordon [48] referred to a spring near Forestburg reported as yielding a "never-failing supply of warm water." In a report on a part of southern Texas, Hill [49] mentioned Comal Springs, with a temperature of 75°, and characterized them as thermal. Although the springs mentioned by Gordon and by Hill may be of artesian character and slightly above the mean annual temperature of the region, they are not considered warm enough to be included in the present list of thermal springs, as the mean annual temperature of northern Texas is about 65° and of southern Texas about 70°.

INTERIOR HIGHLANDS

The Interior Highlands cover southern Missouri, northwestern Arkansas, and eastern Oklahoma and consist of the Ozark Plateaus and the Ouachita province. In this area thermal springs are present only in Arkansas. By far the largest group is at Hot Springs, which was made a Government reserve in 1838. Several years later a general hospital was established there for the Army and Navy. The waters are extensively used by private bathing establishments, and

[46] Darton, N. H., Artesian waters in the vicinity of the Black Hills, S. Dak.: U. S. Geol. Survey Water-Supply Paper 428, pp. 28, 54, 1918.

[47] Peale, A. C., Lists and analyses of the mineral springs of the United States: U. S. Geol. Survey Bull. 32, p. 108, 1886.

[48] Gordon, C. H., Geology and underground waters of the Wichita region, north-central Texas: U. S. Geol. Survey Water-Supply Paper 317, p. 44, 1913.

[49] Hill, R. T., and Vaughan, T. W., Geology of the Edwards Plateau and Rio Grande Plain adjacent to Austin and San Antonio, Tex., with reference to the occurrence of underground water: U. S. Geol. Survey 18th Ann. Rept., pt. 2, pp. 309-312, 1898.

the place is a popular all-year resort. The springs are in the Ouachita Mountains, which consist of a series of ridges formed by the upturned edges of Paleozoic rocks. The geology of the area and the source and temperature of the water have been discussed by Purdue,[50] who concludes that the water collects in an anticlinal valley to the northwest; penetrates down into a syncline and emerges, owing to hydrostatic pressure, in the crest of the plunging anticline at Hot Springs; and that the heat is due chiefly to the depth to which the water descends, where it becomes heated by proximity to underlying masses of hot rock.

Bryan [51] has advanced the theory that some of the water may be of magmatic origin, but he agrees with Purdue as to the structure, which he shows as in figure 10.

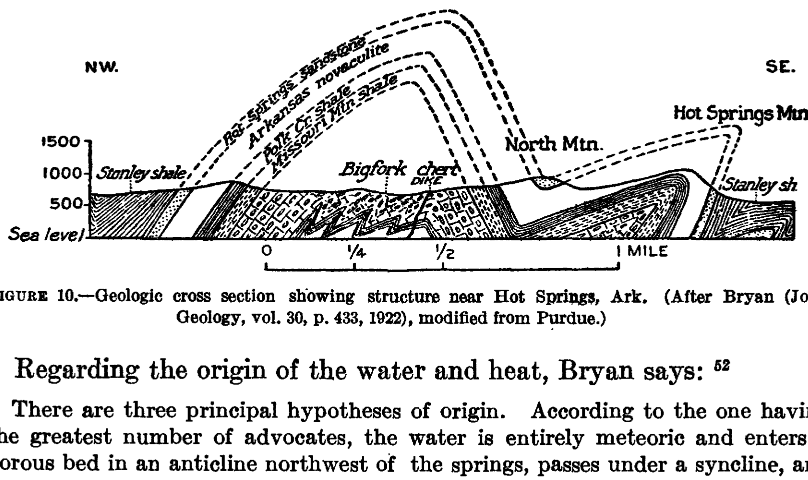


FIGURE 10.—Geologic cross section showing structure near Hot Springs, Ark. (After Bryan (Jour. Geology, vol. 30, p. 433, 1922), modified from Purdue.)

Regarding the origin of the water and heat, Bryan says: [52]

There are three principal hypotheses of origin. According to the one having the greatest number of advocates, the water is entirely meteoric and enters a porous bed in an anticline northwest of the springs, passes under a syncline, and emerges in the next anticline because of hydrostatic pressure. Because the probable depth of the line of travel under the syncline is small and heating of the water by depth alone seems improbable, it is assumed that here the water comes in contact with hot rock, perhaps a cooling plug of igneous origin. However, the lowest part of the anticline in which the water is to gather is lower than the highest of the springs; therefore, there can be no movement due solely to hydrostatic head. Evidence is also brought forward to show that there are other springs of strong flow in the surrounding region of similar mineralization and with temperatures above normal. Therefore, a special mechanism for flow or as a source of heat is invalid, and a general cause, capable of producing all the springs, must be sought. On this account the simple hypothesis that the water is derived from a cooling and crystallizing igneous mass directly under the springs seems unlikely, for it would be necessary to postulate several such masses distributed over an area 50 miles in diameter, and there is no other evidence of igneous activity save the dikes and stocks, previously referred to, which are of Cretaceous

[50] Purdue, A. H., The collecting area of the waters of the hot springs, Hot Springs, Ark.: Jour. Geology, vol. 23, pp. 278–285, 1910; U. S. Geol. Survey Geol. Atlas, Hot Springs folio (no. 215), p. 11, 1923.

[51] Bryan, Kirk, The hot-water supply of the Hot Springs, Ark.: Jour. Geology, vol. 30, pp. 425–449, 1922; The hot springs of Arkansas: Idem, vol. 32, pp. 449–459, 1924.

[52] Bryan, Kirk, Jour. Geology, vol. 32, pp. 450–451, 1924.

age. It seems more likely that in the Pleistocene uplift of the region deep fissures or faults were formed of which no surface expression has been discovered. These fissures doubtless extend into the deep interior of the earth, whence juvenile water rises and, mixed with meteoric water, comes to the surface through shattered rock at the end of the Hot Springs anticline.

At three places 35 to 50 miles south of west from Hot Springs there are small springs with temperatures notably above normal. As the geologic conditions are similar to those near Hot Springs, these minor springs probably have similar origins to those of the larger group.

At Rice's Spring, near the north border of Arkansas (see pl. 8), noticeably thermal water issues. The rocks of the vicinity are Ordovician limestone, and the temperature of 82° suggests that the water rises from a considerable depth, either along fault fissures or from artesian structure. There probably are a few other springs in this region with temperatures appreciably above normal, which have not been reported. Three others with temperatures only slightly above normal were listed by Bryan.[53]

ROCKY MOUNTAIN SYSTEM

The Rocky Mountain System comprises the chain of mountains lying just west of the Great Plains region. It is divided into three provinces—(1) the Northern Rocky Mountains and (2) the Southern Rocky Mountains, two areas of complex mountains of various types with intermontane basins; separated by (3) the Wyoming Basin, an area of high plains in various stages of erosion with isolated low mountains. In the Wyoming Basin province there are only a few thermal springs; in the two Rocky Mountain provinces there are a great many, as shown on plate 11.

NORTHERN ROCKY MOUNTAINS

Of all the physiographic or geomorphic provinces of the United States the Northern Rocky Mountains is perhaps the least unified. Irregular ranges extend southward like great tentacles, including portions of the neighboring plains within their grasp, and detached outliers rise above the hilly country on both sides. Though it is chiefly mountainous, it has extensive intermontane valleys and plains, and it is underlain by a great variety of rocks having complicated structure. It has been found convenient to consider these different topographic areas together, even though it is difficult to characterize the province briefly as a whole; but because of their diversity it is convenient to discuss separately the outstanding topographic and geologic features.

[53] Bryan, Kirk, The hot-water supply of the Hot Springs, Ark.: Jour. Geology, vol. 30, p. 430, 1922.

The mountain forms of northern Montana are in contrast with those of central Idaho. The northern group, extending into Canada, presents a linear arrangement of its elements, so that several parallel ranges are recognized. The ranges are separated by well-defined valleys, some of which contain long, narrow lakes. In northern Montana the easternmost chain facing toward the Great Plains is the Lewis Range, a high barrier forming the Continental Divide and deeply dissected by streams and carved by great valley glaciers. Most of the thermal springs of Montana lie within this area and are associated with faults and igneous intrusions. Among these are the hot springs near Boulder, which issue from fissures in granite. These springs are especially noted for the fact that they are depositing minerals at the present time. Alhambra Hot Springs, Hapgood Hot Springs, and several others are scattered through the area.

West of the front ranges of northern Montana and parallel with them is a long valley that extends southward to the Idaho boundary. This is the Rocky Mountain trench, with a flat floor underlain by alluvial deposits, allowing easy communication and highly developed agriculture. The cities of Kalispell, Missoula, and Hamilton lie in this valley. Conditions are unfavorable for thermal springs, and none have been reported in this area. Farther west are the Purcell Mountains, with accompanying smaller ranges and the rather indistinct Purcell trench. Beyond, in northeastern Washington, is the Selkirk Range. Camas Hot Springs, in Montana, lie in this province and are said to issue near a diorite sill. Granite or Lo-Lo Hot Springs, in Idaho, are also within the province. Their water issues from granite near its contact with sedimentary rocks.

The mountain mass of central Idaho consists of a maze of peaks with no discernible scheme of arrangement. The Coeur d'Alene, Clearwater, and Bitterroot Mountains lie near the Montana boundary, and farther south are the Salmon River Mountains. There are many hot and warm springs in this area, but few of them have been improved commercially. Information concerning most of those listed was supplied by the rangers of the United States Forest Service. There probably are others outside the national forests, which are known only locally. A feature of this region is that many of the springs issue from granitic rocks, as indicated in figure 11. Comparatively few of the thermal springs of Idaho issue from the basaltic lavas, which cover extensive areas. The group of hot springs near Hailey is in some respects typical of the area. These issue at a maximum temperature of 136°, from gravel near exposures of slate, and have long been developed.

East of the Missouri River is the Big Belt Range, which is the largest of the outlying ranges in Montana. A few warm springs are found in these outliers, associated with folds and faults.

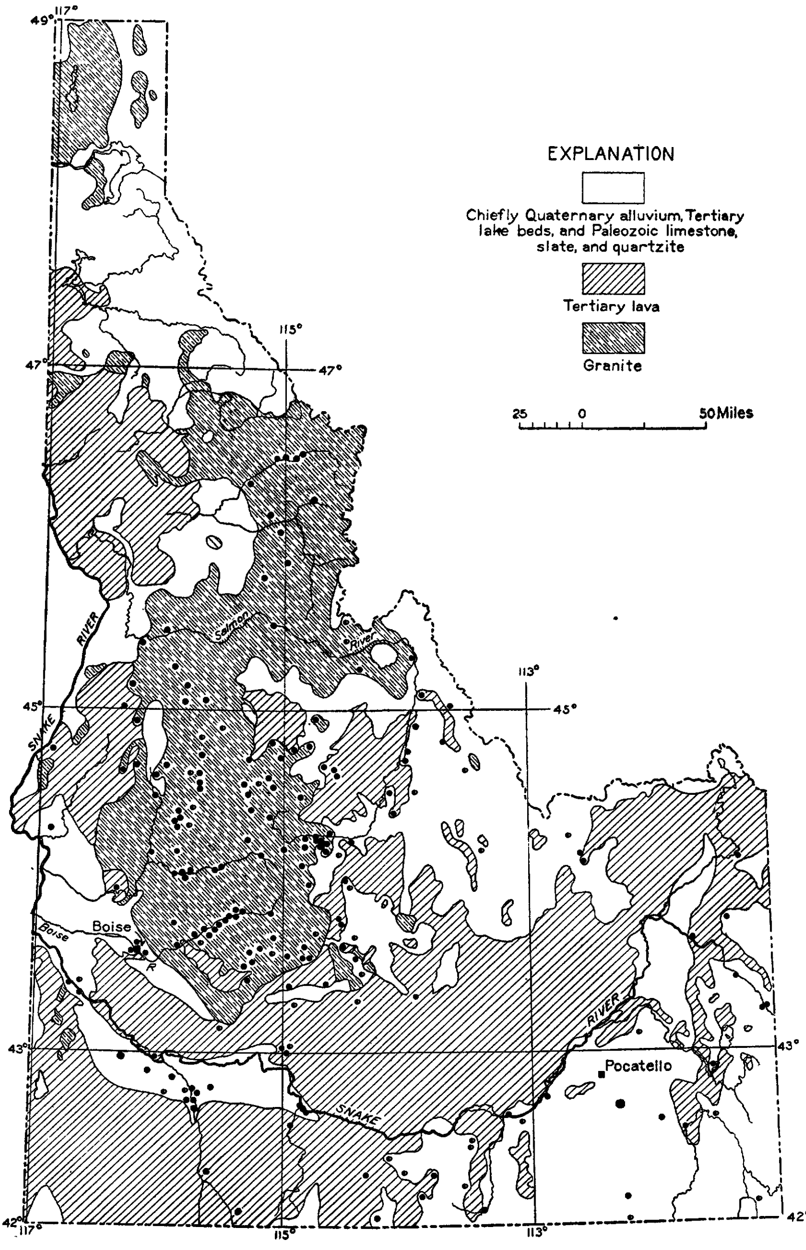


FIGURE 11.—Map of Idaho showing distribution of thermal springs (dots) and principal areas of granite and of lava.

MAP OF IDAHO, MONTANA, AND WYOMING SHOWING THERMAL SPRINGS.

Numbers refer to table in text.

In northwestern Wyoming is the Yellowstone National Park which lies on a plateau surrounded by mountain ranges. On the east is the high Absaroka Range, through which the Shoshone River Canyon provides an entrance to the area. On the south rise the majestic Teton Mountains. In southern Idaho these break into a series of minor ranges, which extend southward into Utah and form the Wasatch Mountains. The spur projecting into the Green River Basin of southern Wyoming forms the Wind River Mountains.

The area was studied in great detail by Hague,[54] who wrote several reports on it. He concluded that all the heated water is of meteoric origin and derives its high temperature from contact, in its underground travel, with lava that has not yet cooled to normal temperature.

Other papers on the subject have been written by Peale,[55] Weed,[56] Jagger,[57] Gautier,[58] Schlundt and Moore,[59] Van Orstrand,[60] and Allen and Day.[61]

The central portion of the park may be described as a broad volcanic plateau lying between 7,200 and 8,300 feet above sea level, with an average altitude of nearly 8,000 feet. On the south, east, north, and northwest of this plateau rise mountain ranges with peaks and ridges 2,000 to 4,000 feet above the general level of the enclosed area.

All the geysers and most of the hot springs are in the western part of the park, the most notable geysers being within the areas known as Lower, Midway, and Upper Geyser Basins, as indicated on plate 12. The most notable "paintpots" are farther north, in Gibbon Meadows; and the most prominent spring deposits are near the north edge of the park, at Mammoth Hot Springs, which are shown in plate 7. It is estimated that there are about 3,000 individual hot springs, geysers, mud springs or "paintpots," and vapor vents or fumaroles within the park, but the number is constantly changing as new vents break forth and old ones cease to flow.

The main areas of volcanic rocks in the park consist of rhyolite, and within them are the geyser basins and most of the hot springs.

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[54] Hague, Arnold, Weed, W. H., and Iddings, J. P., U. S. Geol. Survey Geol. Atlas, Yellowstone National Park folio (no. 30), 1896; Geology of Yellowstone National Park: U. S. Geol. Survey Mon. 32, 1899. Hague, Arnold, The origin of the thermal springs in the Yellowstone National Park: Geol. Soc. America Bull., vol. 22, pp. 103–122, 1911; Geological history of the Yellowstone National Park, Nat. Park Service, 1912.

[55] Peale, A. C., U. S. Geol. and Geog. Survey Terr. 12th Ann. Rept., for 1878, pt. 2, pp. 63–454, 1883.

[56] Weed, W. H., Geysers: Smithsonian Inst. Ann. Rept., 1891, pp. 163–178.

[57] Jagger, T. A., Jr., Some conditions affecting geyser eruption: Am. Jour. Sci., 4th ser., vol. 5, pp. 323–333, 1898.

[58] Gautier, Armin (translated and condensed by F. L. Ransome), The genesis of thermal waters and their connection with volcanism: Econ. Geology, vol. 1, pp. 688–697, 1906.

[59] Schlundt, Herman, and Moore, R. B., Radioactivity of the thermal waters of Yellowstone National Park: U. S. Geol. Survey Bull. 395, 1909.

[60] Van Orstrand, C. E., Temperatures in some springs and geysers in Yellowstone National Park: Jour. Geology, vol. 32, pp. 194–225, 1924.

[61] Allen, E. T., The classification of the hot areas in the Yellowstone Park and the causes of their development [abstract]: Washington Acad. Sci. Jour., vol. 18, no. 19, p. 511, 1928. Allen, E. T., and Day, A. L., Hot springs of the Yellowstone National Park: Carnegie Inst. Washington Pub. 466, 1935.

There is evidence that hot-spring activity has gone on for a long period. It is stated by Hague that the decomposition of the lavas of the rhyolite plateau has proceeded on a gigantic scale and has taken place during a long period of time, which represents the dissipation of vast quantities of heat. It is believed by Daly [62] that the rhyolite grades downward into a batholith and that this batholith furnishes the heat of the thermal activity.

In its underground course through the siliceous rocks the hot water dissolves considerable silica, and some of the springs and geysers deposit large amounts of siliceous sinter around their vents. Mammoth Hot Springs issue through limestone, and the water has taken much lime into solution, which is redeposited as the water cools and evaporates. Thus have been formed Jupiter Terrace, Minerva Terrace (pl. 7), Liberty Cap, and other notable deposits of calcium carbonate tufa in the locality.

The reader is referred to the recent report by Allen and Day, which gives a large amount of original data on the springs and geysers of the area and critical discussion of the data.

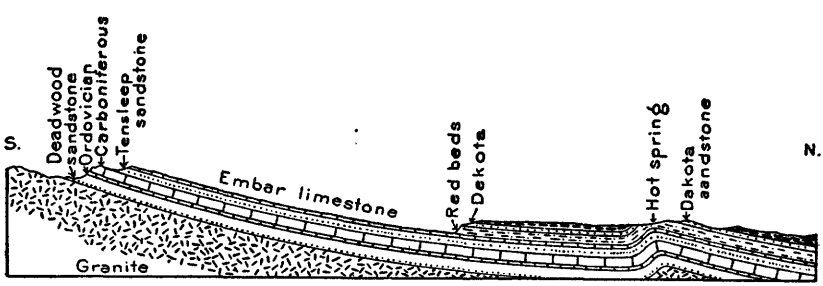
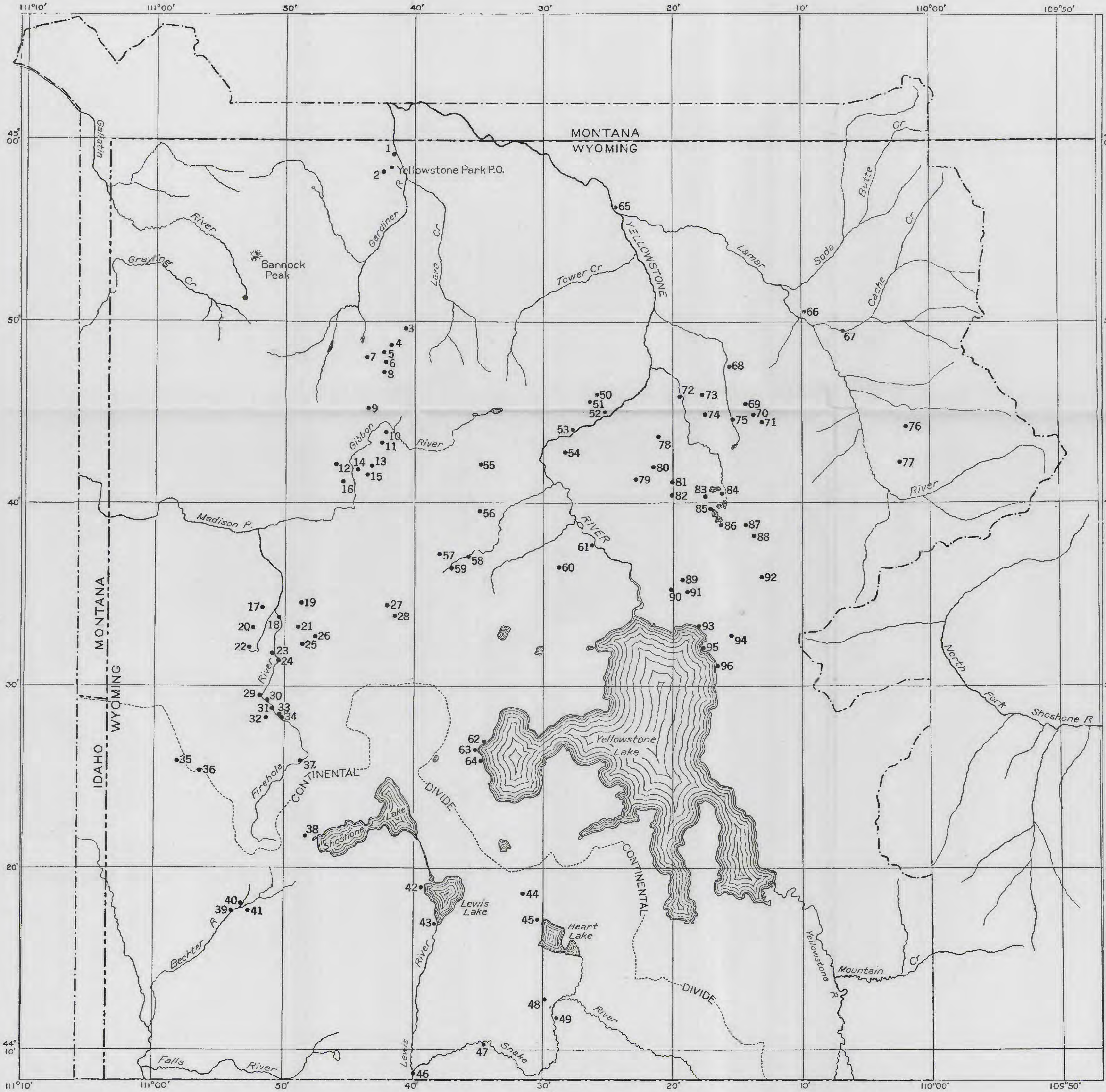


FIGURE 12.—Geologic cross section through the hot springs at Thermopolis, Wyo. (After Darton (Jour. Geology, vol. 14, p. 195, 1906).)

Outside of Yellowstone National Park thermal springs are not very common in Wyoming. Perhaps the best known are the Big Horn Hot Springs, at Thermopolis, near the center of the State. These springs issue from Triassic red beds of the Chugwater formation, near the axis of an anticlinal fold. The geology of the locality has been described by Darton,[63] whose cross section showing the geologic structure is reproduced in figure 12. The temperature of the water, 136°, and the large discharge indicate that it comes from a considerable depth and from a large source, probably the Tensleep sandstone. The springs were included in a State reserve in 1897 and shortly after were improved as a State park, with ample bathing facilities. In later years sanitariums have also been established.

[62] Daly, R. A., The nature of volcanic action: Am. Acad. Arts Sci. Proc., vol. 47, pp. 47-122, 1911.

[63] Darton, N. H., The hot springs at Thermopolis, Wyo.: Jour. Geology, vol. 14, pp. 194-200, 1906; Geology of the Owl Creek Mountains: 59th Cong., 1st sess., S. Doc. 219, p. 39, 1906.



MAP OF YELLOWSTONE NATIONAL PARK SHOWING PRINCIPAL GROUPS OF HOT SPRINGS AND GEYSERS.

PRINCIPAL HOT-SPRING GROUPS

1. Mammoth Hot Springs (160°)
2. Boiling River
3. 3 miles east of Crystal Spring
4. At north base of The Landmark
5. East side of Lake of the Woods
6. 1 mile southeast of Lake of the Woods
7. Amphitheater Springs
8. Whiterock Springs
9. Bijah Spring and Fryingpan Springs
10. Congress Pool
11. Vixen Geyser
12. Sylvan Springs
13. East side of Gibbon Meadows
14. Artists Paintpots
15. Geyser Springs
16. Monument Geysers and Beryl Spring
17. Queens Laundry
18. River Group
19. Morning Mist Springs
20. Fairy Springs
21. Fountain Geyser and Fountain Paintpot
22. Spray Geyser and Imperial Geyser
23. Excelsior Geyser (193°)
24. Midway Geyser Basin
25. Great Fountain Geyser, The Dome, and The Diamond
26. Hot Lake
27. Tributary of Spruce Creek
28. Juniper Creek
29. Biscuit Basin and Jewel Geyser
30. Gem Pool
31. Grotto Geyser (201°) and Punch Bowl
32. Sunset Lake and Rainbow Pool
33. Giantess Geyser (200°)
34. Old Faithful Geyser (200°)
35. 1 mile west of Summit Lake
36. 1 mile south of Summit Lake
37. Lone Star Geyser
38. Shoshone Geyser Basin
39. Bechter River
40. Near Three River Junction
41. Near Tendoy Falls
42. West side of Lewis Lake
43. South end of Lewis Lake
44. Heart Lake Geyser Basin
45. Rustic Geyser
46. Near junction of Snake and Lewis Rivers
47. Snake Hot Springs
48. Basin Creek
49. 1 mile below mouth of Basin Creek
50. Washburn Hot Springs and Inkpot
51. Sulphur Creek
52. Near mouth of Sulphur Creek
53. Half a mile northeast of Inspiration Point on both sides of Yellowstone River
54. Forest Springs
55. 4 miles southwest of Yellowstone Falls
56. Violet Springs
57. Highland Hot Springs
58. Alum Creek
59. 1 mile northeast of Mary Lake
60. Elk Antler Creek
61. Mud Volcano (188°) and Dragons Mouth Spring (170°)
62. Near Bluff Point
63. West shore of Yellowstone Lake
64. Paintpots on west shore of Yellowstone Lake (200°)
65. Yellowstone River, 1 mile below mouth of Slough Creek
66. Near Lamar River, 1 mile below mouth of Cache Creek
67. Wahb Springs
68. Middle part of Deep Creek
69. Upper part of Deep Creek
70. Tributary of Upper Deep Creek
71. Near headwaters of Deep Creek
72. Whistler Geyser and Josephs Coat Spring
73. 2 miles east of Whistler Geyser
74. 2½ miles southeast of Whistler Geyser
75. Hot Spring Basin
76. Tributary of Miller Creek
77. West slope of Saddle Mountain
78. Moss Creek
79. Bog Creek
80. Head of tributary of Sour Creek
81. Tributary of Sour Creek
82. Sour Creek
83. Ponuntpa Springs
84. Near east end of Fern Lake
85. North end of White Lake
86. South end of White Lake
87. The Mudkettles
88. Mushpots
89. Near west end of Sulphur Hills
90. Ebro Springs
91. Vermilion Springs
92. Pelican Springs
93. Beach Springs
94. Turbid Springs
95. Steamboat Springs
96. Butte Springs

The water is heavily charged with calcium carbonate and has formed an extensive deposit of calcareous tufa. Several wells were drilled in the vicinity of the springs to augment the supply and succeeded in obtaining large artesian flows of hot water without appreciably affecting the discharge of the springs. The wells were drilled to the Tensleep sandstone, which was reached at a depth of less than 1,000 feet.

Fort Washakie Hot Springs, 100 miles southeast of the Yellowstone National Park, issue from Quaternary deposits near Triassic red beds, on the axis of an anticline.

Demaris Hot Springs, near Cody, in the northwestern part of the State, but 40 miles east of the Yellowstone National Park, issue from limestone underlying Triassic red beds. According to Fisher,[64] the temperature of the water, 98° F., suggests that it comes from the Tensleep sandstone, which is there at a depth of about 2,200 feet. The water is moderately sulphureted but not strongly mineralized. A sanitarium has been established at the springs for many years. Near them, and also near the springs at Thermopolis, there are sulphur deposits, which have been described by Woodruff.[65]

Structurally the Big Horn Range, which swings in a great arc through north-central Wyoming, forms a dome similar to the Black Hills of South Dakota but of much greater size and elongation. For the most part the sedimentary formations have been eroded from its crest, so that the core of granite is exposed in the highest peaks. Few warm springs are known in this region.

In the northeast corner of Utah the Uinta Mountains form another elongated dome. Unlike most of the mountains of the western United States, this range trends east and west. It serves as a convenient line of demarcation between the Wyoming Basin and the Colorado Plateaus, to the south, but it is considered to be an offshoot from the Northern Rocky Mountains. Its summit still preserves the sedimentary cover, but the crystalline rocks beneath are exposed in the great Canyon of Lodore, cut by the Green River across the east end of the range. No thermal springs have been reported in this area.

WYOMING BASIN

The Wyoming Basin covers most of south-central Wyoming. It consists of high plains in various stages of erosion, with isolated low mountains. The plains owe their flatness to the general horizontal position of the underlying Tertiary and Cretaceous rocks. The flat, monotonous region is broken at long intervals by hills of eruptive

[64] Fisher, C. A., Geology and water resources of the Bighorn Basin, Wyo.: U. S. Geol. Survey Prof. Paper 53, pp. 61-62, 1906.

[65] Woodruff, E. G., Sulphur deposits at Cody, Wyo.: U. S. Geol. Survey Bull. 340, pp. 451-456, 1907; Sulphur deposits near Thermopolis, Wyo.: U. S. Geol. Survey Bull. 380, pp. 373-380, 1909.

materials and by lines of sand dunes. The few thermal springs that lie near the borders of this province seem to be associated with the mountain ranges.

SOUTHERN ROCKY MOUNTAINS

The Southern Rocky Mountains province is usually described as including the series of lofty elongated ridges extending from Wyoming into northern New Mexico. This belt as a whole has a dome structure. The sedimentary strata dip away from the flanks of the mountains but no longer extend over them. Both the Colorado Plateaus and the Great Plains contain the same formations, but these do not join because they are interrupted by the mountain chains rising between them. These elongated mountains comprise two parallel ranges, the Sawatch Range on the west and the Front Range on the east. Each is essentially a dome, and between them is an intervening series of basins or "parks." These parks represent slightly downwarped portions in the center of the main uplift, in which remnants of the former cover are still preserved. In Colorado close to the New Mexico border, along the margin of the Great Plains, there rises a group of ancient volcanoes known as the Spanish Peaks, whose lava flows now form extensive mesas or tablelands. The San Juan Mountains form another irregular mass in southern Colorado and northern New Mexico.

A detailed study of the geologic structure of the beds from which the mineral and thermal springs of Colorado issue has been made by Lakes.[66] The following extracts are taken from his papers:

> Nearly all of the hot springs in Colorado are in the mountains, either on the flanks or more generally deep into the heart of the ranges. They are all associated with areas of great disturbance, sometimes characterized by more or less volcanic activity. The rocks in which they occur are highly tilted and often folded and faulted. Some of the rocks are metamorphic or show signs of incipient metamorphism; a few are strictly igneous and volcanic.
>
> A brief review of the geological conditions and surroundings of some of the best-known hot springs in Colorado * * * shows that these springs derive their heat more from the great depth of their fissures, or from latent heat caused by folding or faulting of the rocks, than from any direct volcanic source.
>
> In a mountainous disturbed and volcanic region like that of the Rocky Mountains of Colorado hot and cold mineral springs abound. Some of them are in the disturbed granitic and volcanic rocks; others are where sedimentary rocks have been greatly uptilted and fissured. A favorite zone in Colorado for the occurrence of both hot and cold springs charged with carbonic and sulphureted hydrogen gas is at the line of juncture between the Dakota Cretaceous sandstone and the overlying Benton or Colorado Cretaceous shales. In all cases the springs occur where these rocks have been highly tilted and disturbed. In some cases they are hot and in others cold, but in all cases they are highly charged with

[66] Lakes, Arthur, Geology of the hot springs of Colorado and speculations as to their origin and heat: Colorado Sci. Soc. Proc., vol. 8, pp. 31-38, 1905; The hot and mineral springs of Routt County and Middle Park, Colo.: Min. Reporter, vol. 52, p. 438, 1905; Mineral and hot springs in Colorado: Min. World, vol. 24, pp. 359-360, 1906.

MAP OF UTAH, COLORADO, ARIZONA, AND NEW MEXICO SHOWING THERMAL SPRINGS.

Numbers refer to table in text.

sulphureted hydrogen and other gases. Along the eastern foothills from north to south of the State, mineral springs occur at intervals along this zone between the Dakota and the Benton group. The hot sulphur springs of Pagosa, on the other side of the main range, are also in this zone, and those in Middle Park and in Routt County along the line of the Moffat road are in identically the same geological zone and position. It would seem as if the Benton and Dakota groups were the special mineral and hot and gaseous geological spring zone of Colorado. The heat of these springs may be derived from latent volcanic bodies, from the great depths of the fissures, or from chemical heat produced by chemical reaction of the ingredients of the springs; the latter are undoubtedly derived from the elements of the rocks through which they ascended.

A detailed report on the mineral waters of Colorado [67] contains information on 254 springs in the State and analyses of 202 of them, including nearly all the thermal springs in Colorado listed in the present report and indicated on plate 13.

The hot springs at Ojo Caliente, in Taos County, N. Mex., notable for their mineral deposits, have been described by Lindgren.[68] The springs issue along the west bank of Ojo Caliente Creek, from tuffaceous lake sediments, above which rise bluffs of gneiss cut by pegmatite. This rock contains veins carrying small amounts of gold and silver, which were prospected in the early days. About 500 feet above the present springs there is a large deposit of calcareous tufa, where the hot water evidently issued at a former time. The mineral veins formed the conduit through which the hot water reached the surface. Fluorite (calcium fluoride) was deposited in the veins by the hot water, and tufa of calcium carbonate was deposited on the surface.

The springs figure in the early records of New Mexico and were visited by the Spanish explorers. The ruins of Indian dwellings nearby show that the springs were also used by the ancient people. For many years they have been developed as a resort. In recent years five springs, with temperatures of 98° to 113°, have been used, the total discharge being about 350 gallons a minute. The water is of the sodium carbonate type but is chiefly notable for its high content of silica and fluoride.

Farther south, in the Jemez Plateau, there are several thermal springs, which have been studied by Kelley and Anspach.[69] Several miles to the northwest a test well for oil, drilled in 1926, struck large flows of hot water at depths of 900 to 1,900 feet. In 1934 this well was discharging about 1,350 gallons a minute of brackish water having a temperature of 140°.

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[67] George, R. D., and others, Mineral waters of Colorado: Colorado Geol. Survey Bull. 11, 1920.

[68] Lindgren, Waldemar, The hot springs of Ojo Caliente and their deposits: Econ. Geology, vol. 5, pp. 22-27, 1910.

[69] Kelley, Clyde, and Anspach, E. W., A preliminary study of the waters of the Jemez Plateau, N. Mex.: New Mexico Univ. Bull. 71, Chem. series, vol. 1, no. 1, 1913.

INTERMONTANE PLATEAUS

Between the Rocky Mountain System on the east and the Cascade Range and Sierra Nevada on the west are the Intermontane Plateaus, in which mountains are either absent or are isolated in relatively small ranges separated by desert plains. The division consists of the Columbia Plateaus, the Colorado Plateaus, and the Basin and Range province.

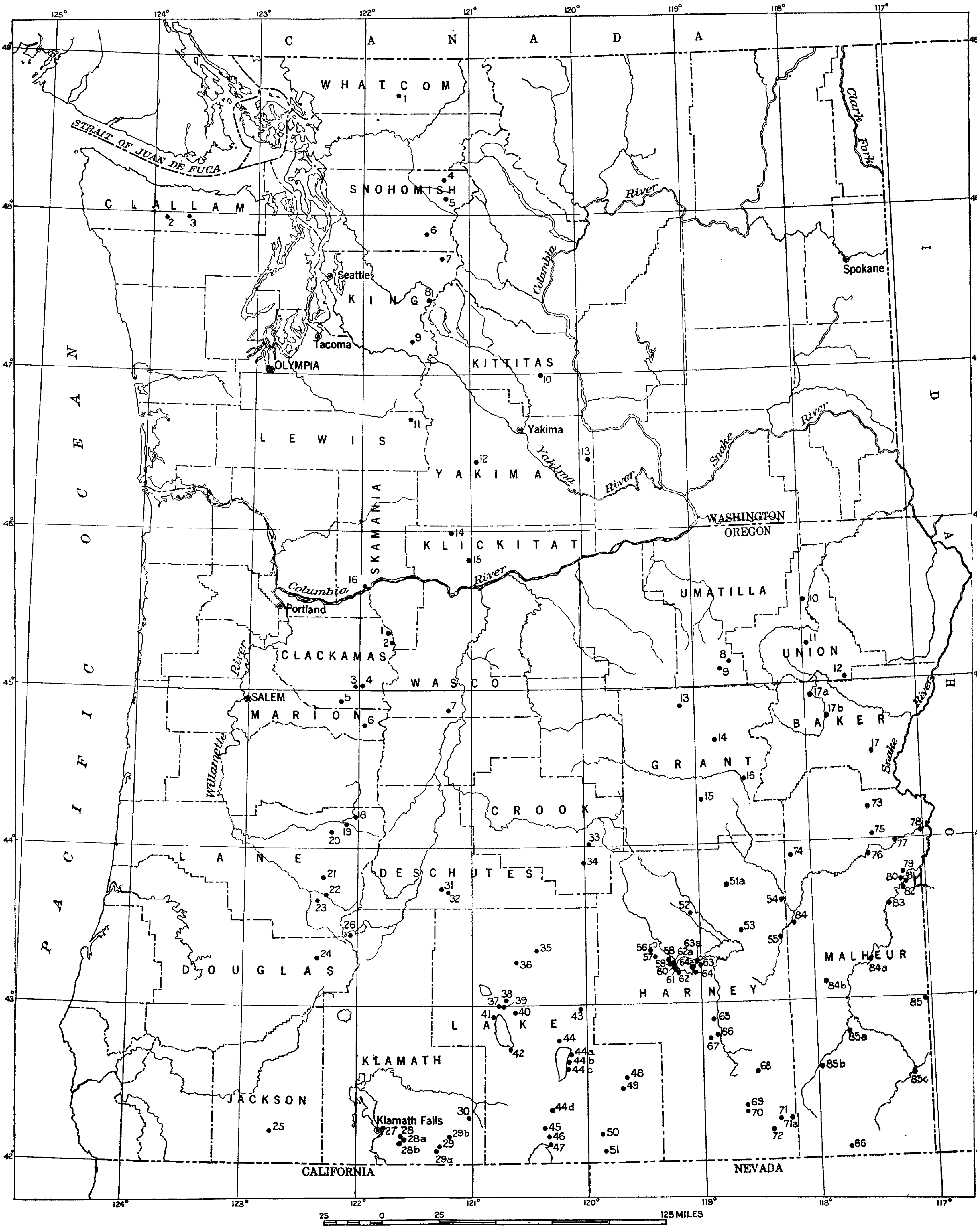
COLUMBIA PLATEAUS

The Columbia Plateaus province extends through eastern Washington, eastern Oregon, and southern Idaho. It includes a large variety of physical features whose basis of unity lies in their common association with the widespread sheets of basaltic lava that form the larger part of the region. In sharp contrast to the mountainous borders are the flat or nearly flat basalt plains, which cover an area of over 250,000 square miles and form probably the most extensive single field of flat-lying basalt in the world. The distribution of thermal springs in southern Idaho is shown in plate 11 and figure 11. The thermal springs of Washington and Oregon are shown in plate 14.

The repeated and extensive outpourings of lava resulted in widespread hydrographic changes. The ancestral Snake River was dammed by lava flows to such an extent that a large lake, called Lake Payette, was formed, upon whose floor sediments were laid down. The lake seems to have been invaded time and again by lava flows, and the lake sediments are interbedded with these flows and with widespread sheets of volcanic sand and dust. In addition to this main lake there were formed many small lake basins, caused by lava dams at the valley mouths, as in Long Valley, in the northern part of Boise County, Idaho. Several hot springs issue along the axis of this valley and are probably associated with faults along its border.

Although the basalt plains were formed in a nearly horizontal position, there are now many marked departures from horizontality. The Snake River Plain now has the form of a broad, shallow basin reaching from the Lost River and Sawtooth Mountains on the north to Goose Creek and the Bear River Mountains on the south. In southwestern Idaho the lavas and intercalated lake and river sediments have been gently flexed, and near the bases of the bordering mountains they have been broken and faulted. It is noticeable that thermal springs are not common within the basalt area of the Snake River Plain, but are present around its border, in the zone of disturbance and faulting. (See fig. 11.)

In western Idaho artesian structure is associated with some of the thermal springs. In the Bruneau Valley faults occur in the lake beds and volcanic rocks, along which there are hot and warm springs. In Goose Creek Valley faults are present in the surface rhyolite and Miocene sediments, and the underlying Paleozoic rocks are believed



MAP OF WASHINGTON AND OREGON SHOWING THERMAL SPRINGS.

Numbers refer to table in text.

to be the source of a few thermal springs. In general the thermal springs in the Columbia Plateaus province are associated with faults, especially along the borders of the lava plains.

In eastern Oregon there are large warm springs near Malheur and Harney Lakes and along the valleys of Malheur and Owyhee Rivers. Some of them issue from tuffaceous material interbedded with lava at the base of bluffs. It is probable that faults are associated with most of these springs, although some may be due to artesian structure.

The Blue Mountains of northeastern Oregon lie midway between the mountains of central Idaho and the Cascade Range. They form a projecting spur of the great earth block comprising the Lost River, Bitterroot, Clearwater, and Salmon River Mountains. The sedimentary rocks of which they are chiefly composed have been not only extensively folded but also extensively intruded by granodiorite, diorite, gabbro, and peridotite. Lava flows from fissures on the flanks of the mountains spread over the surrounding country. There are only a few thermal springs in this area. Medical Springs, having a temperature of 140° F. and discharge of several miner's inches, issue from rocks of the greenstone series, as described by Lindgren.[70]

In Washington five warm springs are found in this province. The southernmost, Blockhouse Mineral Springs, are developed as a resort; one is on the Yakima Indian Reservation and is used locally for bathing; and the other three are used for irrigation. The three nearest the mountains issue from Tertiary basalt. The eastern two are in the plains not far from the Columbia River and issue from the Ellensburg formation, of Miocene sediments interbedded with tuff and lava. The larger one, Clerf Spring, seems to be artesian in character. Its original discharge was greatly increased by excavating, as stated by Smith.[71]

COLORADO PLATEAUS

The Colorado Plateaus province is roughly circular and embraces portions of Utah, Arizona, Colorado, and New Mexico. The Grand Wash Cliffs, on the west; the Uinta Mountains, on the north; the Colorado ranges and the trans-Pecos highlands, on the east; and the Arizona Highlands, on the south, are the most conspicuous border features. It is an arid to semiarid region, underlain chiefly by sedimentary formations that range in age from Paleozoic to Tertiary and that are not greatly folded but are somewhat warped and broken and deeply dissected.

[70] Lindgren, Waldemar, The gold belt of the Blue Mountains of Oregon: U. S. Geol. Survey 22d Ann. Rept., pt. 2, p. 641, 1901.

[71] Smith, G. O., Geology and water resources of a portion of Yakima County, Wash.: U. S. Geol. Survey Water-Supply Paper 55, p. 45, 1901.

This province contains comparatively few thermal springs, most of which are near the western margin and are probably associated with faults or nearby areas of disturbed rock. The warm springs in the Sevier Valley, Utah, are associated with faulting at the base of the

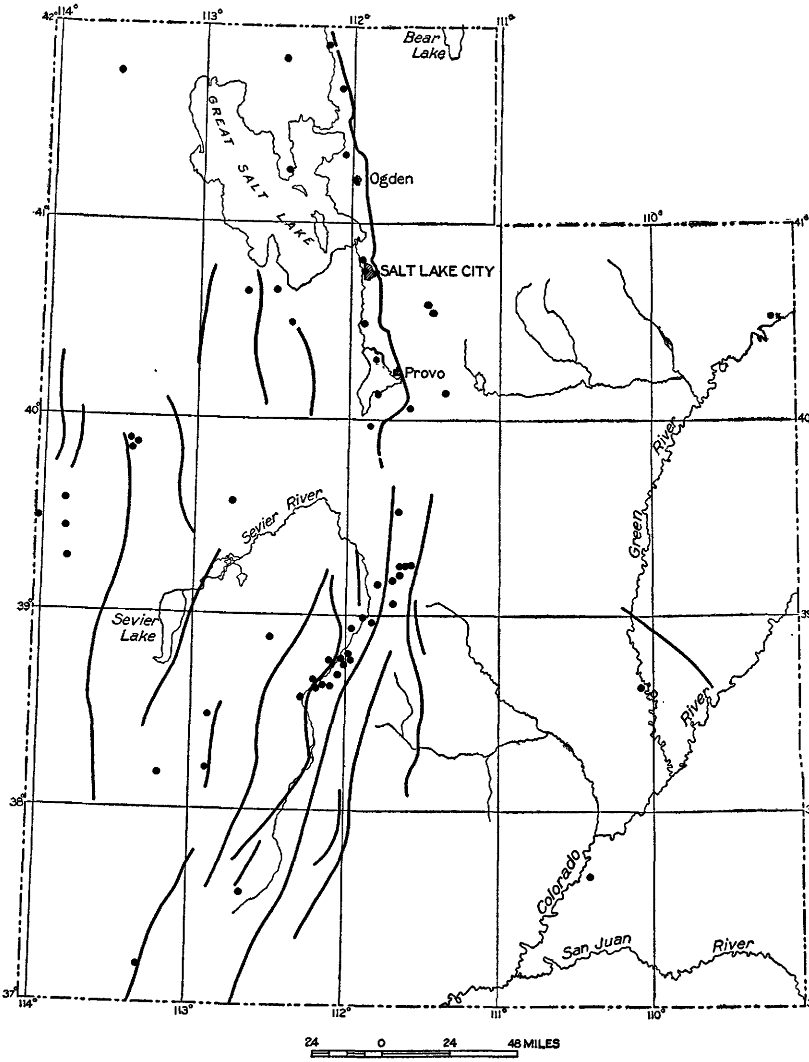


FIGURE 13.—Map of Utah showing thermal springs (dots) and principal faults (heavy lines).

Sevier Plateau, along the zone of the great fault that extends from northern Utah southward along the base of the Wasatch Mountains. The relation of these and other thermal springs in Utah to faults is shown in figure 13.

BASIN AND RANGE PROVINCE

The Basin and Range province is an arid region of isolated ranges that are separated from one another by desert valleys. It comprises parts of Oregon and California, western Utah, most of Nevada, southern Arizona and New Mexico, and western Texas.

The late geologic history of the province has been characterized chiefly by volcanism and block faulting, with the development of aggraded intermontane valleys.

There are many thermal springs in this region, most of which are associated with faults. The thermal springs of Nevada and California are shown on plate 15. The thermal springs near Summer Lake, in Oregon, are notable for their large size. Those near Goose Lake issue along a prominent fault that borders the valley. The groups near Honey Lake, in northeastern California, and Black Rock Desert, in northwestern Nevada, are notable for their high temperature and large discharge. Many of the springs in this region are located along known fault lines, as shown in figure 14.

Fish Springs and Big Spring, in Utah, are near a minor fault line of so recent movement that there is an escarpment in the valley alluvium. The position of these and neighboring springs with relation to the fault has been described and illustrated by Bryan.[72]

Southwestern Arizona comprises a region of widely separated short ranges surrounded by desert plains. Only two hot-spring localities are known in this area—Agua Caliente Springs, on the Gila River, and Aguajito Spring, close to the Mexican boundary. The Agua Caliente Springs issue at a maximum temperature of 104°, near an area of Quaternary lava. They have been developed as a resort. The Aguajito Spring is a small warm spring issuing near hills of schist and is used for water supply and irrigation by the small Indian village of Quitobaquito.

The region called the Salton Trough comprises desert alluvial slopes and the delta plain of the Colorado River, at the head of the Gulf of California. In this area two warm-spring localities are known—Dos Palmas Spring, on the east side of Salton Sea, and Fish Springs, on its western margin. Both rise in the valley alluvium and are probably of artesian character, although possibly Dos Palmas Spring is affected by the Indio fault, which has been described by Brown.[73]

The Mexican Highland, in southeastern Arizona and southwestern New Mexico, is an area of isolated ranges separated by desert plains. Within it there are several thermal springs, some in Arizona and some in New Mexico. Some are in areas of Tertiary lava, and others are near well-recognized faults.

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[72] Bryan, Kirk, Classification of springs: Jour. Geology, vol. 27, pp. 522-561, 1919.

[73] Brown, J. S., Fault features of Salton Basin, Calif.: Jour. Geology, vol. 30, pp. 217-226, 1922.

The southernmost thermal springs in the United States are at two localities within this province, on the western border of Texas. One locality is at the south end of Quitman Mountain, where hot

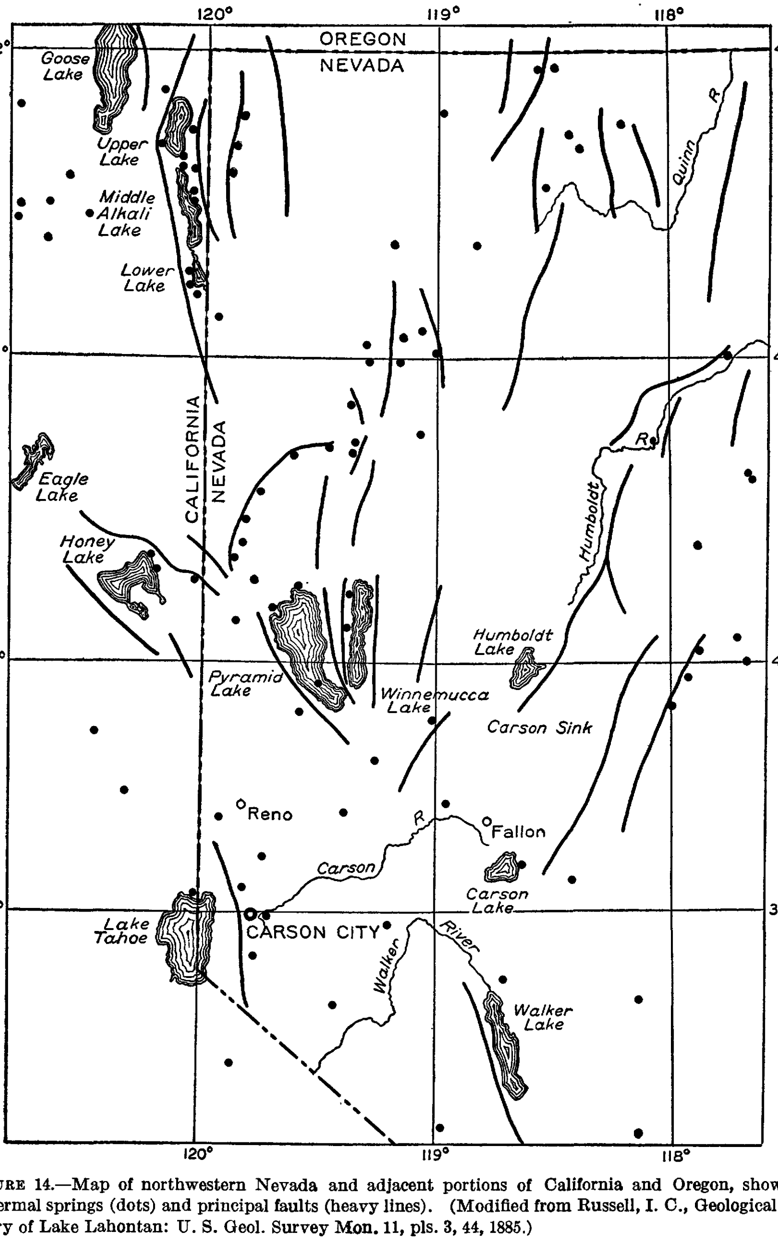


FIGURE 14.—Map of northwestern Nevada and adjacent portions of California and Oregon, showing thermal springs (dots) and principal faults (heavy lines). (Modified from Russell, I. C., Geological history of Lake Lahontan: U. S. Geol. Survey Mon. 11, pls. 3, 44, 1885.)

springs issue at two or more places near the bank of the Rio Grande, from sandstone and shale of the Trinity group, of Lower Cretaceous

MAP OF CALIFORNIA AND NEVADA SHOWING THERMAL SPRINGS.

Numbers refer to table in text.

age. The other locality is about 30 miles farther southeast and 5 miles from the river. The water there issues from Quaternary alluvium that overlies rocks of the Trinity group, which are probably faulted.

PACIFIC MOUNTAIN SYSTEM

The Pacific Mountain System comprises the mountains and valleys in the western parts of Washington, Oregon, and California. Two main physiographic provinces are recognized in it—the Sierra-Cascade Mountains and the Pacific Border province. The mountains of the Pacific Mountain System assume the form of an elongated letter H. Along the Pacific coast from Washington to southern California are the Coast Ranges; parallel with them on the east are the Sierra Nevada and the Cascade Range; and connecting these two zones is the Klamath Mountain area, in northern California and southern Oregon. Between the Sierra Nevada and the Coast Ranges is the long depression forming the California Trough. Corresponding with this in the north is the Willamette Valley of Oregon and its extension in the low region of Puget Sound.

SIERRA-CASCADE MOUNTAINS

The Sierra Nevada is essentially a huge, somewhat wedge-shaped block of the earth's crust. Toward the east its towering summits overlook the Great Basin, but toward the west its gentle slope passes gradually downward beneath the alluvial deposits of Sacramento and San Joaquin Valleys. Great canyons seam the uplands that constitute much of its area. Along the summit of the range there rises a chain of peaks that includes Mount Whitney, the highest peak in the United States outside of Alaska.

The Cascade Range has an aspect different from the Sierra Nevada in several respects, for the upland surface that characterizes it is level but is surmounted by a chain of volcanic peaks. Between the Cascade Range and the Sierra Nevada, however, the mountain chain breaks down and allows the Pit River to pass through, between the volcanic masses of Mount Shasta on the north and Lassen Peak on the south. In addition, numerous cinder cones of comparatively recent origin are distributed over this volcanic field.

The Cascade Range is believed to have been formed not mainly by the piling up of volcanic material but by the broad uplift and deformation of the lava, granite, and sedimentary rocks. The great volcanoes that appear to be such prominent features of the range are secondary to the main mountain forms, which consist of deeply entrenched valleys and sharp ridge crests having approximately equal altitudes. It has also been found that the structure of the range is highly complex and that the conception of a warped monoclinal fault block sculptured by erosion, such as is properly applied to the

Sierra Nevada, requires considerable modification when applied to the Cascade Range.

The northern part of the Cascade Range, in northern Washington, comprises sharp alpine summits of approximately equal height, with higher volcanic cones. Many thermal springs issue along its western slopes, most of them rather closely following the course of the range. Several are reported to issue from granite; the others are in areas of Tertiary basalt, which covers much of the region.

The middle part of the Cascade Range, in Oregon and southern Washington, is characterized by summits of about equal altitude, with higher volcanic cones. Several hot and warm springs occur in this area, issuing from lava. A group in the southeastern part of Clackamas County, Oreg., and Foley Springs and Belknap Hot Springs, farther south, in Lane County, are well known and have been developed as resorts.

The southern part of the Cascade Range lies chiefly in north-central California and comprises eroded volcanic mountains that do not form a distinct range. Mount Shasta and Lassen Peak lie within this area. Thermal springs issue near Lassen Peak and are believed to be closely associated with the volcanic activity and with faults, as discussed by Day and Allen.[74] The position of the springs with reference to the peak (which was active at intervals from May 30, 1914, to about June 1917) and to the probable faults is shown in plate 16.

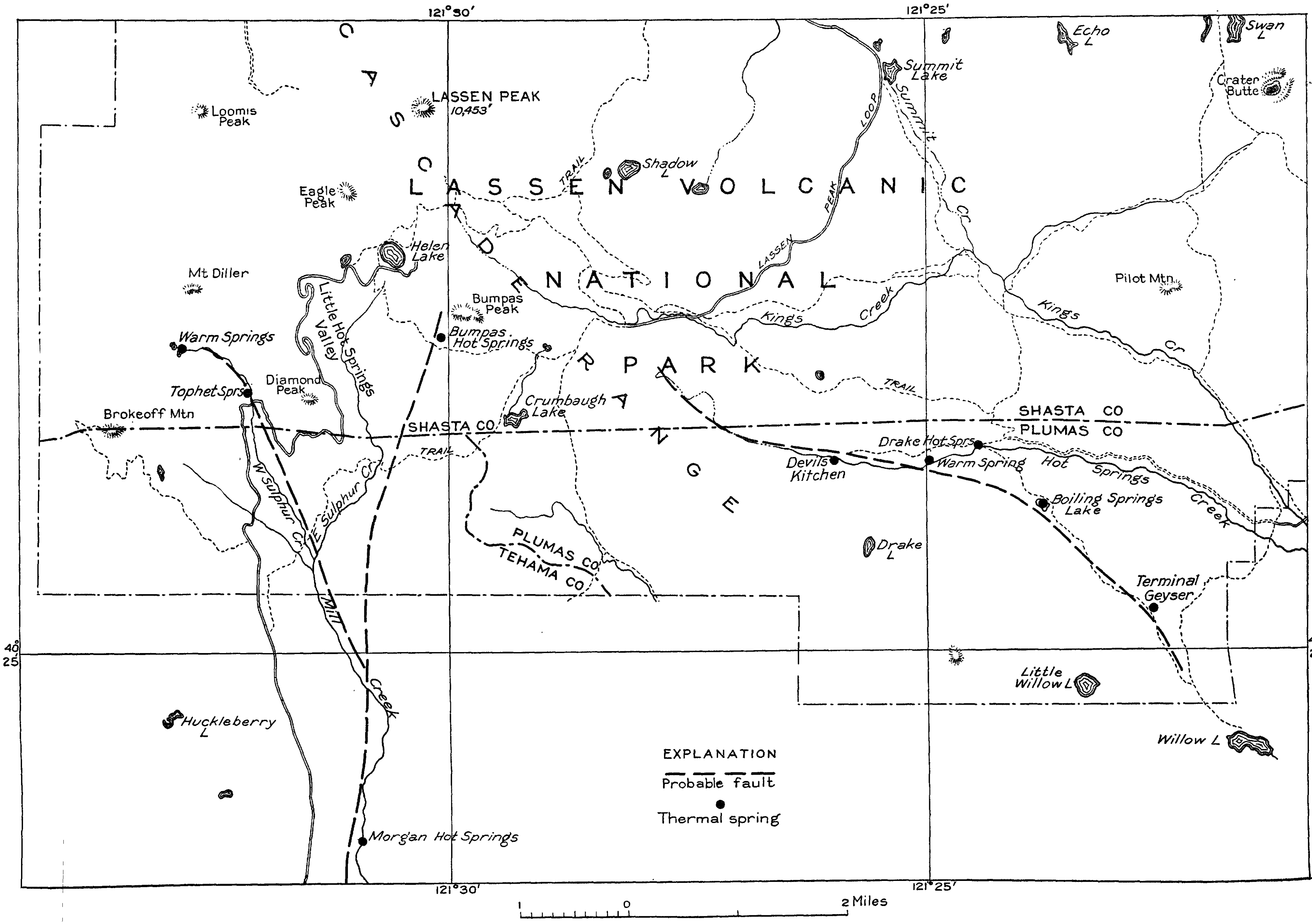
The Sierra Nevada consists of a block-mountain range tilted westward, with the crests of the main ridges and peaks along its east border. A few thermal springs are found in these mountains, chiefly in the eastern part. Most of the springs are associated with faults or with volcanic rocks.

PACIFIC BORDER PROVINCE

The Pacific Border province comprises the coastal ranges extending from northwestern Washington to southern California, the elongated troughs of Puget Sound in Washington and the Willamette Valley in Oregon, and the Great Valley of California.

In northwestern Washington two groups of hot springs issue from pre-Tertiary metamorphic rocks of the Olympic Mountains. Both have been developed within recent years as resorts, the western group being known as Sol Duc Hot Springs and the other as Olympic Hot Springs. Both are probably associated with close folds or with faults, as the temperature of the water is 125° to 132°. No thermal springs are known in the coastal ranges of Oregon and only one small warm spring in northwestern California.

[74] Day, A. L., and Allen, E. T., The volcanic activity and hot springs of Lassen Peak: Carnegie Inst. Washington Pub. 360, p. 87, 1925.



MAP OF LASSEN PEAK AREA, CALIFORNIA, SHOWING THERMAL SPRINGS AND THEIR RELATION TO THE PEAK AND TO PROBABLE FAULTS.

In the coast ranges north of San Francisco Bay there are many thermal springs, some of which are highly mineralized. Several of them are closely associated with faults and with mineral deposits—facts that were early recognized. Becker [75] noted the presence of hot springs at some of the quicksilver deposits of the area, and Fairbanks [76] called attention to the deposition of gold in Cretaceous rocks near Sulphur Creek.

The hot springs and fumaroles at The Geysers, in Sonoma County, Calif., have been studied by Allen and Day,[77] who note that these thermal springs and others issue along a fault that extends for at least 25 miles along the west side of the St. Helena Range.

Southward along the coast ranges of California to the Mexican border there are many other hot springs. Most of these seem to be related to fault zones. Many of the springs are developed as resorts, a much larger proportion of the thermal springs in California being so improved than in regions that are not so advantageously situated for commercial development.

SUMMARY AND CONCLUSIONS

The information that has been collected on the location, temperature, and other features of the thermal springs is presented in tabular form on pages 115–191. As this information has been compiled from various sources, it may contain some errors, but care has been taken to prevent duplications and omissions, so far as possible. The sources of information are indicated by reference numbers, which correspond to the numbers of the items in the annotated bibliography, and the publications cited that contain analyses are indicated by an asterisk (*). Data on many thermal springs, especially in Idaho, Montana, Nevada, New Mexico, and Oregon, have been obtained in the field or from unpublished records of the Geological Survey, Forest Service, Office of Indian Affairs, and General Land Office.

The number of thermal springs is not a definite figure; for in many localities it is a matter of choice whether several vents are considered to represent separate springs or to constitute one spring group. Neither is the number constant, for in some places, notably in the Yellowstone National Park and to a less extent near Lassen Peak, Calif., and in several areas where the hot water deposits much tufa of calcium carbonate, old vents become clogged and new ones may be opened. In some regions, as in Virginia and West Virginia, and in some areas of alluvial artesian springs, the gradation of tempera-

[75] Becker, G. F., Summary of the geology of the quicksilver deposits of the Pacific slope: U. S. Geol. Survey 8th Ann. Rept., pt. 2, pp. 961–985, 1889.

[76] Fairbanks, H. W., Some remarkable hot springs and associated deposits in Colusa County, Calif.: Science, new ser., vol. 23, pp. 120–121, 1894.

[77] Allen, E. T., and Day, A. L., Steam wells and other thermal activity at "The Geysers", Calif.: Carnegie Inst. Washington Pub. 378, 1927.

ture from cool to warm springs is so gradual that a sharp distinction cannot be made, and the designation as thermal is somewhat arbitrary.

The following table shows the approximate extent to which the springs were developed for economic use in 1936.

Summary of known thermal springs in the United States

State	Developed		Not used	Total
	Resorts	Used for bathing, irrigation, or water supply		
Arizona	5	9	7	21
Arkansas	2	1	3	6
California	53	89	42	184
Colorado	17	16	12	45
Georgia	2	5	1	8
Idaho	16	67	120	203
Massachusetts	----------	1	----------	1
Montana	18	20	2	40
Nevada	15	93	66	174
New Mexico	5	15	18	38
New York	1	----------	----------	1
North Carolina	1	----------	----------	1
Oregon	14	73	18	105
Pennsylvania	----------	1	----------	1
South Dakota	1	2	----------	3
Texas	----------	3	----------	3
Utah	7	43	13	63
Virginia	7	13	----------	20
Washington	8	5	3	16
West Virginia	4	6	----------	10
Wyoming:				
Outside of Yellowstone National Park	5	10	5	20
In Yellowstone National Park	3	----------	93	96
Total	184	472	403	1,059

Of the 1,060 thermal springs in the United States recorded below, 645 issue from igneous rocks. This number would be several thousand if the individual thermal springs in Yellowstone National Park were counted separately instead of by groups. Probably many of the remaining 415 thermal springs described as issuing from other kinds of rocks owe their heat to adjacent hot igneous rocks. There can be no doubt that most of the thermal springs derive their temperature from magma that is still cooling. Few if any of the thermal springs apparently obtain their heat from lava flows, because practically all the flows in the United States are sufficiently old to have had ample time to cool. The large number of thermal springs that issue from the great batholith of Idaho indicate that such huge intrusive masses cool very slowly and may remain hot enough to supply heat to thermal springs for millions of years. The Pleistocene basalts of the Columbia River Plateau contain practically no thermal springs because they were spread out in relatively thin sheets that cooled quickly, because their feeders were generally thin dikes that likewise cooled quickly, and because in most places they contain large quantities of ground water which mix with and cool to normal temperatures any hot water that rises from the underlying rocks. A considerable number of the thermal springs issue along faults, but for many of these fault springs it is difficult to determine whether the heat is derived from hot gases or liquids rising along the faults from underlying bodies of hot rock, from the frictional heat developed by the displacement, or from artesian systems in which vents have been produced by the faulting. The fact that many of the faults associated with hot springs occur in regions of igneous intrusive rocks strongly suggests that most of these springs owe their high temperature to underlying bodies of hot rock. Relatively few thermal springs are apparently due to artesian structure, and such springs are generally only warm rather than hot, as, for example, the thermal springs of Virginia. Thus folding is not of major importance as a geologic process in the formation of thermal springs.

Geysers occur in only a few places in the United States, apparently because there are only a few localities where the temperature near the surface is sufficiently high to convert ground water into steam. A small cold-water spring called Steamboat Springs, near Soda Springs, Idaho, exhibits geyser action, but this is caused by the intermittent release of carbon dioxide gas. Other so-called "geysers" that discharge cold water were found on investigation to be intermittent or ebbing and flowing springs, presumably operating on the siphon principle, as, for example, "The Geyser" near Afton, Wyo.[78]

Borings in several of the thermal areas have revealed superheated steam in the pores and crevices. Present scientific knowledge of the gases exhaled by cooling magmas favors the belief that a large part and possibly all this superheated steam is of magmatic origin. Ground water of meteoric origin evaporated by this ascending undersaturated superheated steam accounts for the formation of many of the thermal springs in regions of cooling igneous rocks.[79] On the basis of this study of the thermal springs of the United States there can be little doubt, however, that the greater part of the water discharged by these springs is of meteoric origin.

The measured or estimated discharge of 725 of the thermal springs, as given in this report, amounts to 449,758 gallons a minute, or 1,002 cubic feet a second. The flow of 126,000 gallons a minute from 29 springs in Montana is the largest reported total discharge for any State. Warm Springs Creek in Fergus County, Mont., with a temperature of only 68° F. and a discharge of 80,000 gallons a minute, is probably the largest thermal spring in the United States. The average discharge of 177 out of a total of 184 thermal springs in California as given in this report, based chiefly on actual measure-

[78] Stearns, N. D., A remarkable intermittent spring: The Mid-Pacific Magazine, vol. 45, no. 3, pp. 216–218, 1933.

[79] Allan, E. T., and Day, A. L., Hot springs of Yellowstone National Park: Carnegie Inst. Washington Pub. 466, p. 39, 1936.

ments, is only 91 gallons a minute. In the following table (pp. 115–191) the reported discharge of many of the springs which lack actual measurements may be too great, and it is therefore estimated that the total flow of all thermal springs in the United States is not more than 500,000 gallons a minute, or approximately the same as the flow of the single cold spring that forms the Malad River near Hagerman, Idaho.

ANNOTATED BIBLIOGRAPHY OF THERMAL SPRINGS IN THE UNITED STATES

ARIZONA

1. Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Clifton folio (no. 129), p. 13, 1905. Describes salt springs near Clifton, tepid to 160°, and gives analysis of water from one spring.

2. Schrader, F. C., Mineral deposits of the Santa Rita and Patagonia Mountains, Ariz.: U. S. Geol. Survey Bull. 582, p. 366, 1915. Describes Agua Caliente Spring, Santa Cruz County, and says that it has been used since earliest settlement.

3. Ross, C. P., The lower Gila region, Ariz.: U. S. Geol. Survey Water-Supply Paper 498, p. 197, 1923. Describes Agua Caliente Springs, Maricopa County, and gives analysis of the water.

4. Bryan, Kirk, The Papago country, Ariz.: U. S. Geol. Survey Water-Supply Paper 499, pp. 164, 426, 1925. Gives history and use of spring near Quitobaquito, Pima County; name probably signifies "little spring."

5. Everit, R. S., Hot-spring water from Clifton, Ariz.: Econ. Geology, vol. 20, p. 291, 1925. Believes the water to be juvenile and connected with late igneous rocks. Clifton hot well is an 18-foot shaft and crosscut in basalt; temperature of water 165°; gives analysis.

5a. Knechtel, M. M., Indian Hot Springs, Graham County, Ariz.: Washington Acad. Sci. Jour., vol. 25, no. 9, 1935. A description of the springs, with analyses of their waters and discussion of their origin.

ARKANSAS

6. Branner, J. C., Mineral waters of Arkansas: Arkansas Geol. Survey Ann. Rept. for 1891, vol. 1, pp. 6–23, 1892. Discusses Hot Springs, Garland County, and gives analyses; the waters are very pure and differ little in composition; probably heated by underlying Silurian rocks.

7. Haywood, J. K., and Weed, W. H., The Hot Springs of Arkansas: 57th Cong., 1st sess., S. Doc. 282, pp. 1–78, 1902. Gives analyses of 46 springs, by J. K. Haywood, and geologic sketch, by W. H. Weed.

8. Boltwood, B. B., On the radioactive properties of the waters of the springs on the Hot Springs Reservation, Hot Springs, Ark.: Am. Jour. Sci., 4th ser., vol. 20, pp. 128–132, 1905. (Also in annual report of the Secretary of the Interior for 1904.) Gives the results of examination made in 1904 on samples from 44 springs.

9. Weed, W. H., Notes on certain hot springs of the southern United States: U. S. Geol. Survey Water-Supply Paper 145, pp. 189–206, 1905. Gives history, management, and geology of the Hot Springs, Ark.; mentions Warm Springs, Ga., and Hot Springs, N. C.

10. Purdue, A. H., The collecting area of the waters of the hot springs, Hot Springs, Ark.: Jour. Geology, vol. 18, pp. 278–285, 1910. Concludes that the collecting area is in a valley to the north and somewhat higher; the water penetrates down into a syncline and rises in the Hot Springs anticline; the location

of the springs is due to the southwest plunge of the anticlinal axis. Suggests that the heat may be due in part to hot rock of numerous dikes.

11. Bryan, Kirk, The hot-water supply of the Hot Springs, Ark.: Jour. Geology, vol. 30, pp. 425–449, 1922. Presents data collected during examination to see if water supply can be increased. Suggests that part of the water may be juvenile; lists four other springs in the State with temperatures of 74° to 97°.

12. Purdue, A. H., U. S. Geol. Survey Geol. Atlas, Hot Springs folio (no. 215), p. 11, 1923. Gives history, development, and data on the springs. Water collects in anticlinal valley to northeast, penetrates down into syncline, and emerges, owing to difference in altitude, in plunging anticline of Hot Springs Mountain. Heated by proximity of underlying masses of hot rock.

13. Bryan, Kirk, The hot springs of Arkansas: Jour. Geology, vol. 32, pp. 449–459, 1924. The hot water rises through fractured sandstone at the nose of a plunging anticline. There are three principal hypotheses of origin. (*a*) The one having most advocates is that the water is entirely meteoric, enters a porous bed in an anticline, passes under a syncline, and emerges in the next anticline because of hydrostatic pressure (gives evidence against this being the full explanation). (*b*) The water is derived from a cooling and crystallizing igneous mass directly under the springs (characterizes this as unlikely and gives reasons against this mode of origin). (*c*) Fault fissures extend into the deep interior, whence juvenile water rises and, mixed with meteoric water, comes to the surface (this hypothesis rests on general argument).

CALIFORNIA

14. Loew, Oscar, Report on the alkaline lakes, thermal springs, mineral springs, and brackish waters of southern California and adjacent country: U. S. Geog. Surveys W. 100th Mer. Ann. Rept. for 1876, pp. 188–199, 1876. Mentions several warm springs and gives analysis of warm spring in Lytle Canyon.

15. Russell, I. C., Geological history of Lake Lahontan: U. S. Geol. Survey Mon. 11, pp. 48–53, pl. 8, 1885. Describes and maps several thermal springs in northeastern California, northwestern Nevada, and southeastern Oregon.

16. Russell, I. C., The Quaternary history of Mono Valley, Calif.: U. S. Geol. Survey 8th Ann. Rept., pt. 1, pp. 261–394, 1889. Gives analysis of warm spring on east shore of Mono Lake; describes hot springs on an island which he named "Paoha" ("children of the mist", a general term for vapors or hot springs); mentions hot springs near Bridgeport.

17. Becker, G. F., Summary of the geology of the quicksilver deposits of the Pacific slope: U. S. Geol. Survey 8th Ann. Rept., pt. 2, pp. 961–985, 1889. Mentions springs of Sulphur Bank and hot spring at Oathill mine; states that Steamboat Springs, Nev., are unquestionably due to volcanic activity.

18. Turner, H. W., Mohawk lake beds: Philos. Soc. Washington Bull., vol. 11, pp. 385–410, 1891. Says that Mohawk Valley is the bed of a Pleistocene lake. The sands are locally cemented by water of McLear Sulphur Springs, where the beds are faulted.

19. Anderson, Winslow, Mineral springs and health resorts of California, 384 pp., San Francisco, 1892. Short descriptions of about 180 springs, of which about 70 are thermal. Gives many analyses, most of which were made by himself or assistants.

20. Fairbanks, H. W., Some remarkable hot springs and associated deposits in Colusa County, Calif.: Science, new ser., vol. 23, pp. 120–121, 1894. Discusses springs in valley of Sulphur Creek and says that it is the only locality in California where gold occurs in veins in Cretaceous rocks.

21. Fairbanks, H. W., Stratigraphy at Slate's Springs, with some further notes on the relation of the Golden Gate series to the Knoxville: Am. Geologist, vol. 18, pp. 350–356, 1896. Describes sheared and silicified beds of "Golden Gate

series" [Franciscan formation], beneath the Knoxville (Cretaceous), resting against the crystalline rocks of the Santa Lucia Range.

22. Arnold, Ralph, Geology and oil resources of the Summerland district, Santa Barbara County, Calif.: U. S. Geol. Survey Bull. 321, 1907. Geology of area of Montecito Hot Springs is shown on plate 1; says (pp. 23–24), "Hot springs emanate from the rocks of the Topatopa formation in Hot Springs Canyon, 4 miles northeast of Santa Barbara."

23. Waring, G. A., Springs of California: U. S. Geol. Survey Water-Supply Paper 338, 410 pp., 1915. Describes 140 groups classed as hot springs; several other thermal springs are described among those classed as sulphur springs and artesian springs.

24. Anderson, Robert, and Pack, R. W., Geology and oil resources of the west border of the San Joaquin Valley north of Coalinga, Calif.: U. S. Geol. Survey Bull. 603, pp. 212–213, 1915. States that Mercey Hot Springs issues from base of a terrace deposit resting on fractured greenstone. The water probably rises along a fault.

25. Waring, G. A., Ground water in the San Jacinto and Temecula Basins, Calif.: U. S. Geol. Survey Water-Supply Paper 429, pp. 24, 25, 43, 44, 1919. Contains descriptions of Eden, Relief (San Jacinto), and Soboba (Ritchey) hot springs, warm springs on Indian Creek, and hot springs of the Pilares.

26. Ellis, A. J., and Lee, C. H., Geology and ground waters of the western part of San Diego County, Calif.: U. S. Geol. Survey Water-Supply Paper 446, pp. 205–206, 1919. Gives data on Agua Caliente (Warner Hot Springs).

27. Thompson, D. G., Routes to desert watering places in the Mohave Desert region, Calif.: U. S. Geol. Survey Water-Supply Paper 490, pp. 87–269, 1921. Gives a short description (p. 269) of Yeoman Spring, San Bernardino County.

28. Noble, L. F., Mansfield, G. R., and others, Nitrate deposits in the Amargosa region, southeastern California: U. S. Geol. Survey Bull. 724, p. 24, 1922. Mentions Saratoga Spring and says that the water is brackish but potable.

29. Brown, J. S., The Salton Sea region, Calif.: U. S. Geol. Survey Water-Supply Paper 497, 1923. Describes Palm Springs (p. 198), the original spring being a small flow of tepid sulphureted water; Fish Springs (p. 203), submerged by rise of Salton Sea in 1906, were again exposed in 1918; gives analyses of both springs (pp. 282–283).

30. Day, A. L., and Allen, E. T., The sources of heat and the source of water in the hot springs of the Lassen National Park: Jour. Geology, vol. 32, pp. 178–190, 1924. Conclude that the source of the heat is volcanic but that the springs are fed chiefly by surface water; a minor part of the water is magmatic.

31. Day, A. L., and Allen, E. T., The volcanic activity and hot springs of Lassen Peak: Carnegie Inst. Washington Pub. 360, 190 pp., 1925. Contains detailed maps of the Devils Kitchen and Bumpas Hell hot-spring areas and analyses of several springs. Says (p. 87) that The Geyser, Boiling or Tartarus Lake, Drake Springs, Devils Kitchen, and Bumpas Hell are along one fault fissure, and that Morgan Hot Springs, Supan Springs, and hot springs farther up Mill Creek are on another fault fissure intersecting the first.

32. Allen, E. T., and Day, A. L., Steam wells and other thermal activity at "The Geysers", Calif.: Carnegie Inst. Washington Pub. 378, 106 pp., 1927. Gives detailed map of the area, with analyses and other data on about 40 hot springs; description of 8 wells drilled to get steam for electric-power development. Gabbro found by the drill at 230 feet shows it to be a volcanic area; a fault along west side of St. Helena Range for 25 miles passes through "The Geysers" and other hot-spring localities. The springs are fed by meteoric water, heated by magmatic steam. Also contains short descriptions of the Little Geysers and hot-water wells drilled near Calistoga.

33. Thompson, D. G., The Mohave Desert region, California: U. S. Geol. Survey Water-Supply Paper 578, 1929. Contains short descriptions of Paradise, Saratoga, Newberry, Soda Station, and Yeoman Springs, San Bernardino County, with analyses of the first three.

COLORADO

34. Hayden, F. V., U. S. Geol. Survey Terr. 4th Ann. Rept., for 1870, 1871. Notes (p. 171) warm springs 1 mile north of Salt Lake City, Utah, and gives analysis; also mentions hot springs 3 miles north of the city. Mentions (p. 199) several springs, 120°, in Sawatch Basin, Colo.

35. Hayden, F. V., U. S. Geol. Survey Terr. 1st, 2d, and 3d Ann. Repts., for the years 1867, 1868, and 1869, 1873. Describes (pp. 162, 164) hot springs 5 miles northwest of Las Vegas, N. Mex., at contact of Carboniferous and gneissic rocks; and hot springs in valley of Las Gallinas Creek. Mentions (pp. 184, 219, 221) hot springs in Colorado on right bank of Grand River, south of Valley of Troublesome Creek, in Middle Park near Mount Bross, at Ojo Caliente, and in Homan's Park.

36. Hayden, F. V., U. S. Geol. and Geog. Survey Terr. 8th Ann. Rept., for 1874, 1876. Mentions (p. 63) several active springs, maximum temperature 104°, on Rock Creek, in Elk Range, Colo.

37. Hayden, F. V., U. S. Geol. and Geog. Survey Terr. 9th Ann. Rept., for 1875, 1877. Mentions two groups of warm springs in White Earth Valley, 80°–84° (pp. 37, 38); says that hot springs at Ouray are in Carboniferous rocks cut by dikes (p. 41); mentions three springs on Hot Springs Creek and gives analyses (pp. 154–155); describes Pagosa Springs, gives analysis, and suggests that chemical action in shales of the Colorado group produces the heat (pp. 183–185).

38. Denison, Charles, Rocky Mountain health resorts, 192 pp., Boston, 1881. Contains short descriptions of hot-spring resorts at 10 places in Colorado and of Ojo Caliente and Las Vegas hot springs, in New Mexico.

39. Wheeler, G. M., U. S. Geog. and Geol. Surveys W. 100th Mer. Final Rept., vol. 1, 1889. Refers to preceding annual reports and mentions warm springs of Crater Mound, in Provo Valley, Utah (p. 47); hot springs at Norman's ranch and Pagosa Springs, in Colorado (pp. 78, 84); and hot springs (150°) 21 miles from Fort Bayard, N. Mex. [Faywood Hot Springs] (p. 122).

40. Lakes, Arthur, Geology of the hot springs of Colorado and speculations as to their origin and heat: Colorado Sci. Soc. Proc., vol. 8, pp. 31–38, 1905. Notes that the springs are in mountain areas where the rocks are folded and faulted; gives data on nine hot-spring localities in the State.

41. Lakes, Arthur, The hot and mineral springs of Routt County and Middle Park, Colo.: Min. Reporter, vol. 52, pp. 438–439, 1905. Gives short description of Hot Sulphur Springs, in Middle Park, and of Steamboat Springs.

42. Lakes, Arthur, Mineral and hot springs in Colorado: Min. World, vol. 24, pp. 359–360, 1906. States that the springs occur where the rocks are highly tilted and folded; especially in the Benton and Dakota "groups." Specifically mentions the warm springs at Moffat Lakes resort, Hot Sulphur Springs, and Steamboat Springs, with analyses of the last two. Steamboat Springs issue from Benton shale and deposit much travertine.

43. Spurr, J. E., and Garrey, G. H., The Idaho Hot Springs mining district, Colo.: U. S. Geol. Survey Bull. 285, p. 37, 1906. Mention hot springs on Soda Creek, which deposit travertine.

44. Cross, Whitman, and Howe, Ernest, U. S. Geol. Survey Geol. Atlas, Ouray folio (no. 153), pp. 19–20, 1907. Say that the springs at Ouray issue from the Ouray limestone, near a fault; one spring has a temperature of 154°; give analysis

of another. The springs near Ridgway are heavily charged with iron, probably derived from red strata of the Cutler formation; early called "Uncompahgre" (red water).

45. Spurr, J. E., Garrey, G. H., and Ball, S. H., Economic geology of the Georgetown quadrangle, Colo.: U. S. Geol. Survey Prof. Paper 63, pp. 163–167, 1908. The Idaho Hot Springs issue near the contact of intrusive syenite with gneiss. The water originally issued 400 feet above the present valley and gradually descended with erosion. The hot water is carbonated and has deposited much tufa.

46. Siebenthal, C. E., Geology and water resources of the San Luis Valley, Colo.: U. S. Geol. Survey Water-Supply Paper 240, pp. 102–104, 112, 1910. Describes Dexter warm spring and Chamberlain and Valley View hot springs, and gives analyses.

47. George, R. D., and others, Mineral waters of Colorado: Colorado Geol. Survey Bull. 11, 474 pp., 1920. List and describe 254 springs (pp. 202–248), including nearly all the thermal springs, and give 202 analyses (pp. 249–468) of the spring waters.

48. Bastin, E. S., Silver enrichment in the San Juan Mountains, Colo.: U. S. Geol. Survey Bull. 735, pp. 65–129, 1923. Gives analyses (p. 67) of four waters from Ouray hot springs; all are similar, are probably deep-seated, and issue from Carboniferous limestone of the Hermosa formation.

49. Campbell, M. R., The Twentymile Park district of the Yampa coal field, Routt County, Colo.: U. S. Geol. Survey Bull. 748, p. 6, 1923. Notes that Steamboat Springs issue from Dakota sandstone.

50. Hancock, E. T., Geology and coal resources of the Axial and Monument Butte quadrangles, Moffat County, Colo.: U. S. Geol. Survey Bull. 757, p. 77, 1925. Says that the water of Juniper Hot Springs probably comes from the Dakota sandstone.

GEORGIA

[See also reference 9]

51. Duggan, J. R., The mineral springs of Georgia, 56 pp., Macon, Ga., J. W. Burke & Co., 1881. Primarily a medical essay on therapeutics of mineral waters. Describes 28 springs, including Thundering Spring and Warm Springs.

52. Fuller, M. L., Contributions to the hydrology of the eastern United States: U. S. Geol. Survey Water-Supply Paper 102, pp. 230–231, 234, 1904. Gives a short description of Warm Springs, Meriwether County.

53. Hall, B. M. and M. R., Water resources of Georgia: U. S. Geol. Survey Water-Supply Paper 197, pp. 14, 241, 1907. Give discharge measurements of Warm Springs (1.47 to 3.2 second-feet).

54. McCallie, S. W., A preliminary report on the underground waters of Georgia: Georgia Geol. Survey Bull. 15, pp. 243–245, 1908. Gives data and analyses of Lifsey, Thundering, and Warm Springs.

55. McCallie, S. W., Mineral springs of Georgia: Georgia Geol. Survey Bull. 20, pp. 102, 157, 166, 1913. Contains more data than reference 54, on Lifsey, Thundering, and Warm Springs, which are classed as the only thermal springs in the State; says that temperature of Warm Springs (87°) indicates that the water comes from a depth of about 1,500 feet; Thundering Spring (76°) and Lifsey Spring (77°) from less than 700 feet.

56. Watson, T. L., Thermal springs of the southeast Atlantic States: Jour. Geology, vol. 32, pp. 373–375, 1924. Notes that there are several thermal springs in Virginia, three in Georgia, and one in North Carolina; gives analyses of the last four.

IDAHO

57. Hayden, F. V., U. S. Geol. and Geog. Survey Terr. 11th Ann. Rept., for 1877, 1879. F. M. Endlich mentions hot springs in Wyoming 2 miles west of Camp Brown (pp. 16, 55, 86) and on Beaver Creek (pp. 27, 55, 77). A. C. Peale mentions hot springs at five localities in Idaho (pp. 562, 591–594) and warm springs at mouth of Cottonwood Creek, Gentile Valley, Idaho (p. 601), which are carbonated and deposit tufa.

58. Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Boise folio (no. 45), p. 7, 1898. Describes Boise Hot Springs, 4½ miles southeast of Boise, and mentions small tepid spring in Cottonwood Creek 1 mile from the city, and hot springs in Squaw Creek, 3 miles north. Also states that wells 400 to 450 feet deep, 2 miles southeast of the city furnish 550 gallons a minute of water at 170°, used for heating and domestic supply in Boise.

59. Russell, I. C., Geology and water resources of the Snake River Plains of Idaho: U. S. Geol. Survey Bull. 199, pp. 166–169, 1902. Gives data on warm and hot springs at 10 localities in the area. States that Boise Hot Springs and others near Boise are on a fault.

60. Russell, I. C., Preliminary report on artesian basins in southwestern Idaho and southeastern Oregon: U. S. Geol. Survey Water-Supply Paper 78, pp. 26–27, 1903. Mentions thermal springs at 10 localities in Idaho and at Vale, about 10 miles northwest of Vale, and near Beulah, in Oregon.

61. Lindgren, Waldemar, and Drake, N. F., U. S. Geol. Survey Geol. Atlas, Silver City folio (no. 104), p. 5, 1904. Mentions a spring at 67°, of considerable volume, near Walters Butte; a spring at 128°, on the Snake River near Enterprise; and wells near Enterprise and Guffey that yield warm water.

62. Lindgren, Waldemar, A geological reconnaissance across the Bitterroot Range and Clearwater Mountains in Montana and Idaho: U. S. Geol. Survey Prof. Paper 27, p. 113, 1904. Gives short descriptions of hot springs at seven localities in Idaho.

63. Washburne, C. W., Gas and oil prospects near Vale, Oreg., and Payette, Idaho: U. S. Geol. Survey Bull. 431, pp. 33–35, 1911. Mentions hot springs at seven localities in the Vale area and says there are many others in the surrounding region; mentions hot springs 7 miles southwest of Owyhee and 6 miles northeast of Weiser, Idaho.

64. Umpleby, J. B., Ore deposits in the Sawtooth quadrangle, Blaine and Custer Counties, Idaho: U. S. Geol. Survey Bull. 580, p. 223, 1915. Mentions hot springs at three places in the area—near its north edge, southwest of Carrietown, and on Wood River; temperature 125° to 150°.

65. Schultz, A. R., A geological reconnaissance for phosphate and coal in southeastern Idaho and western Wyoming: U. S. Geol. Survey Bull. 680, p. 31, 1918. States that springs at 94°–117°, in T. 39 N., R. 116 W., Wyo., are on Darby fault. In Idaho, springs at Heise (110°) are on the same fault; in T. 2 N., R. 43 E., there are extinct hot-spring deposits; and in T. 1 N., R. 43 E., and T. 2 S., Rs. 45 and 46 E., there are warm springs.

66. Piper, A. M., Geology and water resources of the Goose Creek Basin, Cassia County, Idaho: Idaho Bur. Mines and Geology Bull. 6, pp. 58, 60–63, 1923. Gives data on Land, Poulton, Oakley, and Thoroughbred Springs, with analyses of the first three, and data on four thermal springs in the northeast corner of Nevada.

67. Meinzer, O. E., Ground water in Pahsimeroi Valley, Idaho: Idaho Bur. Mines and Geology Pamph. 9, pp. 31, 32, 1924. Says that Sulphur Creek Spring discharges several second-feet; its temperature (57°) is about 15° above normal and indicates a moderately deep source. There is a warm spring in the Little Lost River Valley about 6 miles from the summit; temperature 79½°.

68. Piper, A. M., Geology and water resources of the Bruneau River basin, Owyhee County, Idaho: Idaho Bur. Mines and Geology Pamph. 11, pp. 36–38, 1925. Gives data on nine thermal springs in the area.

69. Umpleby, J. B., and others, The geology and ore deposits of the Wood River region, Idaho: U. S. Geol. Survey Bull. 814, pp. 115–117, 1930. Mentions hot springs at four localities (Guyer, Clarendon, and Hailey Hot Springs, and springs near the west edge of the area) and gives analyses of the first three.

MONTANA

70. Clarke, F. W., and others, Report of work done in the division of chemistry and physics: U. S. Geol. Survey Bull. 27, p. 75, 1886. Gives analyses of waters from White Sulphur Springs and from Matthews Warm Springs, near Bozeman.

71. Weed, W. H., and Pirsson, L. V., Geology of the Castle Mountain mining district, Mont.: U. S. Geol. Survey Bull. 139, pp. 149–150, 1896. Describe White Sulphur Hot Springs, give analyses, and say that the heat is probably due to volcanism.

72. Peale, A. C., U. S. Geol. Survey Geol. Atlas, Three Forks folio (no. 24), p. 5, 1896. Describes Ferris Hot Springs (formerly Matthews Warm Springs), 7 miles west of Bozeman; and three other springs farther west (1 mile southwest of Red Bluff, 5 miles south of Pony, and in lower canyon of Jefferson River).

73. Weed, W. H., and Pirsson, L. V., Geology and mineral resources of the Judith Mountains of Montana: U. S. Geol. Survey 18th Ann. Rept., pt. 3, p. 453, 1898. Says that Warm Spring Creek, near Maiden, rises in springs.

74. Weed, W. H., U. S. Geol. Survey Geol. Atlas, Little Belt Mountains folio (no. 56), p. 8, 1899. Gives data on White Sulphur Springs, with analysis; and states that the water rises clear but becomes opalescent or milky from suspended sulphur.

75. Weed, W. H., Mineral-vein formation at Boulder Hot Springs, Mont.: U. S. Geol. Survey 21st Ann. Rept., pt. 2, pp. 233–255, 1900. Presents detailed contour map of the area and discusses the quartz and jasper veins in the granite.

76. Weed, W. H., Gypsum deposits in Montana: U. S. Geol. Survey Bull. 223, p. 74, 1904. Describes the gypsum deposits at Hunter's Hot Springs, on the north bank of the Yellowstone River, 20 miles east of Livingston.

77. Weed, W. H., Economic value of hot springs and hot-spring deposits: U. S. Geol. Survey Bull. 260, pp. 598–604, 1905. States that the alum-bearing water of Sun River Hot Springs furnishes a residue that is sold at a high price. Like Steamboat Springs, Nev., and Sulphur Bank, Calif., which are noted for their metalliferous deposits, Boulder Hot Springs and Anaconda Hot Springs, in Montana, are of scientific interest, although their metalliferous content is minute. At Anaconda Hot Springs there is an old travertine area overlying a deposit of limonite, used as flux at Washoe smelter. At Hunter's Hot Springs are extensive veins of gypsum, with veinlets of stilbite (a zeolite); gives analysis of the water.

78. Calvert, W. R., Geology of the Lewistown coal field, Mont.: U. S. Geol. Survey Bull. 390, pp. 11, 12, 38, 1909. Notes that 7 miles above Lewistown several large warm springs form Warm Spring Creek. Travertine deposits in T. 15 N., R. 20 E., probably were made by former hot springs.

79. Campbell, M. R., and others, Guidebook of the western United States, Part A, The Northern Pacific Route, with a side trip to Yellowstone Park: U. S. Geol. Survey Bull. 611, p. 92, 1915. Mentions Corwin Springs and hotel, a bathing resort.

80. Meinzer, O. E., Artesian water for irrigation in Little Bitterroot Valley, Mont.: U. S. Geol. Survey Water-Supply Paper 400, pp. 9–37, 1917. States that Camas Hot Springs are near the outcrop of a large diorite sill (p. 20); gives analyses of the waters (p. 29).

81. Stout, Tom, Montana, its story and biography, 3 vols., 1921. Mentions Hunter's, Chico, and Corwin Hot Springs as well-known resorts (vol. 1, p. 801); mentions Camas Hot Springs, being developed under lease from Department of the Interior (p. 823); lists 19 principal hot-spring resorts (p. 885).

82. Pardee, J. T., Geology and ground-water resources of Townsend Valley, Mont.: U. S. Geol. Survey Water-Supply Paper 539, pp. 47, 53, 57, 1925. Notes Bedford Spring (74°), Mockel Spring (62°), and spring (64°) in sec. 24, T. 5 N., R. 1 E., as being used for irrigation; gives analysis of Mockel Spring, which issues from Madison limestone.

83. Meinzer, O. E., Large springs in the United States: U. S. Geol. Survey Water-Supply Paper 557, pp. 72–87, 1927. Classes Warm Springs, Mont., and Ana River Springs, Oreg., among the largest springs of the country; mentions Ash, Crystal, and Hiko Springs, Nev., as being of large discharge.

NEVADA

[See also references 15, 17, 66, 77, and 83]

84. Hague, Arnold, and Emmons, S. F., U. S. Geol. Expl. 40th Par. Rept., vol. 2, pp. 318–826, 1877. Contains references to seven thermal-spring localities in Utah (pp. 318–354) and 15 localities in Nevada (pp. 540–826). Plate 20 shows Sou Springs, in Osobb Valley, Nev., described (pp. 704–706) as a dozen deep pools on a large tufa mound rising 60 feet above the plain, a quarter of a mile south of rhyolite hills. The temperature of the hottest pools is 160° to 185°. Another group at the point of a diorite spur but probably in close connection with the rhyolite contain strong brine (125°).

85. Becker, G. F., Geology of the quicksilver deposits of the Pacific slope: U. S. Geol. Survey Mon. 13, pp. 338–353, 1888. States that Steamboat Springs issue along fissures and deposit siliceous sinter that contains metallic minerals, including gold, silver, mercury, and lead; gives analyses of water, temperature 167° to 176°. The water is derived from rainfall, hence the flow varies. They are a good example of the formation of fissure veins by hot springs.

86. Spurr, J. E., Descriptive geology of Nevada south of the 40th parallel and adjacent portions of California: U. S. Geol. Survey Bull. 208, pp. 58, 87, 165, 1903. At the north end of the Golden Gate Range is a deposit of tufa covering several square miles, eroded into hills and bluffs, with many hot springs; hot springs and vertical ore deposits along Hot Creek Canyon; Indian Spring and hot spring at White's ranch, in Pahrump Valley.

87. Spurr, J. E., Geology of the Tonopah mining district, Nev.: U. S. Geol. Survey Prof. Paper 42, pp. 254–257, 1905. Discusses conditions producing hot springs; mentions the Devil's Punchbowl, 45 miles northeast of Tonopah, 30 feet in diameter, giving off inflammable gas.

88. Lindgren, Waldemar, The occurrence of stibnite at Steamboat Springs, Nev.: Am. Inst. Min. Eng. Bimonthly Bull. 2, pp. 275–278, 1905. Says that stibnite (antimony trisulphide, Sb_2S_3) is deposited on the surface by hot ascending water; gives analyses of the water.

89. Lindgren, Waldemar, The occurrence of stibnite at Steamboat Springs, Nev.: Am. Inst. Min. Eng. Trans., vol. 36, pp. 27–31, 1905. The springs are 6 miles from the Comstock lode. Water at 176° issues from fissures in granite at the base of a basalt bluff; large deposits of siliceous and calcareous sinter, some colored red by antimony sulphide; hot water in gravel under the sinter; small crystals of stibnite in the gravel.

90. Spurr, J. E., Ore deposits of the Silver Peak quadrangle, Nev.: U. S. Geol. Survey Prof. Paper 55, p. 161, 1906. Mentions hot saline springs at Silver Peak. In Fish Lake Valley there are strongly saline springs, but they are not hot.

91. Bain, H. F., A Nevada zinc deposit: U. S. Geol. Survey Bull. 285, pp. 166–169, 1906. Mentions Indian Spring and the spring at White's ranch, in Pahrump Valley.

92. Ball, S. H., A geological reconnaissance in southwestern Nevada and eastern California: U. S. Geol. Survey Bull. 308, pp. 19–20, 1907. States that Alkali Spring, 11 miles northwest of Goldfield, was developed by a tunnel from an original seep to 85,000 gallons a day; water used at Combination mill; gives analysis of water (sulphureted, 140°). Also mentions Hicks Hot Springs, Staininger Ranch Springs, Grapevine Springs, and those in Ash Meadows; thinks that all are probably due to volcanism.

93. Ransome, F. L., Emmons, W. H., and Garrey, G. H., The geology and ore deposits of Goldfield, Nev.: U. S. Geol. Survey Prof. Paper 66, p. 143, 1909. Mention Alkali Spring, used by the Combination mine, and give analysis.

94. Ransome, F. L., Notes on some mining districts in Humboldt County, Nev.: U. S. Geol. Survey Bull. 414, p. 55, pl. 1, 1909. Gives short description of Sou Hot Springs; several pools 50 feet in diameter, on tufa mounds, maximum temperature 185°. Map (pl. 1) shows several hot and warm springs.

95. Lindgren, Waldemar, The Tertiary gravels of the Sierra Nevada of California: U. S. Geol. Survey Prof. Paper 73, p. 189, 1911. States that Walley's Hot Springs, Nev., issue for 2,000 feet along a fault, with large discharge, used for irrigation; gives analysis; water sulphureted, 146°.

96. Dole, R. B., Exploration for salines in Silver Peak Marsh, Nev.: U. S. Geol. Survey Bull. 530, p. 332, 1913. Mentions hot and cold springs of weak brine at edge of marsh.

97. Kearney, W. M., Biennial report of State engineer of Nevada for 1911–12, p. 249, 1913. Gives discharge measurements of Preston Springs, White Pine County, 6.21 second-feet; Warm Creek at source (Lund Spring), 2.16 second-feet.

98. Carpenter, E. B., Ground water in southeastern Nevada: U. S. Geol. Survey Water-Supply Paper 365, pp. 26, 30, 39, 1915. Describes several springs in the region, both cool and thermal, and gives analyses of Soda Springs and Blue Eagle Springs, Nye County, and Las Vegas Springs, Clark County.

99. Hill, J. M., Some mining districts in northeastern California and northwestern Nevada: U. S. Geol. Survey Bull. 594, p. 171, 1915. Mentions several hot mineralized springs at Sodaville. Plate 9 is a view of Hinds Hot Spring.

100. Knopf, Adolph, Tin ore in northern Lander County, Nev.: U. S. Geol. Survey Bull. 640, pp. 125–138, 1917. Says that the tin ore occurs in hills on the Izzenhood ranch, which is established at a large spring known as "Warm Spring", used for irrigation.

101. Meinzer, O. E., Geology and water resources of Big Smoky, Clayton, and Alkali Spring Valleys, Nev.: U. S. Geol. Survey Water-Supply Paper 423, pp. 88–91, 143, 153, 154, 1917. Describes springs on McLeod ranch, Charnock, Gendron, and Darrough Springs, in Nye County (pp. 88–91). Spencer Hot Springs, Lander County (p. 91); and Waterworks Spring (p. 143) and Alkali Spring (p. 149), Esmeralda County; gives analyses (pp. 153, 154) of the last five; states (p. 92) that Warm Spring, 6 miles west of Cloverdale, has a temperature of only 55°.

102. Waring, G. A., Ground water in Reese River Basin and adjacent parts of Humboldt River Basin, Nev.: U. S. Geol. Survey Water-Supply Paper 425, pp. 95–129, 1918. Describes several thermal springs in the area (pp. 111, 126, 127); gives analyses of two hot springs in T. 27 N., R. 43 E.

103. Waring, G. A., Ground water in Pahrump, Mesquite, and Ivanpah Valleys, Nevada and California: U. S. Geol. Survey Water-Supply Paper 450, pp. 51–86, 1920. Gives data (pp. 63, 77) and analyses (p. 80) of springs at Manse and Pahrump, in the south end of Nye County.

104. Clark, W. O., Riddell, C. W., and Meinzer, O. E., Exploratory drilling for water and use of ground water for irrigation in Steptoe Valley, Nev.: U. S. Geol. Survey Water-Supply Paper 467, pp. 37, 43, 45–49, 1920. Describe and give analyses of several warm and hot springs in the area and state that all are probably situated along faults.

105. Meinzer, O. E., Origin of the thermal springs of Nevada, Utah, and southern Idaho: Jour. Geology, vol. 32, pp. 295–303, 1924. Says that most of the springs are not of artesian origin; many are definitely related to faults, Darrough Hot Springs, Nev., being typical. Deep source and absence of artesian structure seem favorable to theory that the water is juvenile. Describes Spencer Hot Springs, Nev., and reproduces (from reference 101) map of them.

NEW MEXICO

[See also references 35, 38, and 39]

106. Stevenson, J. J., U. S. Geog. and Geol. Surveys W. 100th Mer. Rept., vol. 3, suppl., 1881. Describes (pp. 349–351, 405, 406) Las Vegas Hot Springs, "which issue near contact of Archean and Carboniferous rocks"; gives analyses of three of the springs.

107. Clarke, F. W., Report of work done in the division of chemistry during the fiscal years 1891–92 and 1892–93: U. S. Geol. Survey Bull. 113, p. 114, 1893. Gives analysis of water from Ojo Caliente Hot Springs, Taos County.

108. Jones, F. A., New Mexico mines and minerals, 349 pp., 1904. Chapter 37, "Mineral waters" (pp. 289–312), contains descriptions or mention of 20 thermal-spring localities and several cool mineral springs.

109. Lindgren, Waldemar, The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, pp. 71–73, 1910. Mentions thermal springs of Las Vegas, Faywood, Jemez, and Socorro; describes Ojo Caliente, Taos County, and the gold-and-silver-bearing deposit on the slope above the springs; states that the tufa deposit and fluorite veins were formed by the springs when issuing several hundred feet above their present outlets; gives analyses and notes the high fluorine and boron content, the water being of volcanic type.

110. Lindgren, Waldemar, The hot springs at Ojo Caliente and their deposits: Econ. Geology, vol. 5, pp. 22–27, 1910. States that the springs issue at the foot of a gneiss hill, but from soft sands and tuffs; prospect shaft on hillside, in gneiss cut by pegmatite, on vein carrying gold and silver; calcareous tufa on top of hill, 500 feet above present springs. The mineral vein was the conduit through which hot water reached the surface, depositing calcium fluoride in the vein and calcium carbonate at the surface; analysis of the water shows notable amounts of fluorine and boron.

111. Kelley, Clyde, and Anspach, E. V., A preliminary study of the waters of the Jemez Plateau, N. Mex.: New Mexico Univ. Bull. 71, Chem. ser., vol. 1, no. 1, 72 pp., 1913. Describe and give analyses of 11 springs (two have temperatures of only 51° and 59°; the others 99° to 167°); state that the temperatures of the springs decrease away from Mount Pelado, an old volcano.

112. Darton, N. H., and others, Guidebook of the western United States, Part C, The Santa Fe Route: U. S. Geol. Survey Bull. 613, p. 69, 1916. Mentions Montezuma Hot Springs, a resort 6 miles from Las Vegas.

113. Renick, B. C., Geology and ground-water resources of western Sandoval County, N. Mex.: U. S. Geol. Survey Water-Supply Paper 620, pp. 78, 86–89, 1931. Describes Indian Springs, San Ysidro Springs, and Phillips Springs; gives eight analyses (p. 78) of waters from these groups.

NORTH CAROLINA

[See references 9 and 56]

OREGON

[See also references 15, 60, 63, and 83]

114. Lindgren, Waldemar, The gold belt of the Blue Mountains of Oregon: U. S. Geol. Survey 22d Ann. Rept., pt. 2, pp. 641, 642, 1901. Describes Medical Hot Springs, which issue from greenstone, and mentions other hot springs on the Burnt River at the road crossing in John Day Valley 9 miles above Prairie and on Camp Creek 6 miles south of Susanville.

115. Langille, H. D., and others, Forest conditions in the Cascade Range Forest Reserve, Oreg.: U. S. Geol. Survey Prof. Paper 9, pp. 76, 77, 1903. Mentions hot springs in area of 20 acres in sec. 25, T. 6 S., R. 6 E., and adjacent sec. 30, T. 6 S., R. 7 E., and a hot sulphur spring in sec. 26, T. 7 S., R. 5 E. Describes Breitenbush, Foley, and Belknap Hot Springs, and gives analysis of the Belknap.

116. Russell, I. C., Preliminary report on the geology and water resources of central Oregon: U. S. Geol. Survey Bull. 252, pp. 41, 55, 56, 61, 100, 1905. Considers a hot spring northeast of Saddle Mountain Butte (in Harney Valley) to be a true fissure spring, the source of the water, which has a temperature of 122°, being probably 3,500 feet deep; mentions warm springs at the head of the Crooked River and many small warm springs for 2 miles along Gilchrist Valley, probably artesian, from a depth of 2,500 feet; also artesian spring and wells in Price Valley; and spring (105°), on north border of Pauline Lake, from fissure in basalt.

117. Waring, G. A., Geology and water resources of a portion of south-central Oregon: U. S. Geol. Survey Water-Supply Paper 220, pp. 51–56, 66, 69, 1908. Gives data on warm and hot springs near Lakeview, in the valley of Summer Lake, and near Abert, Christmas, Fossil, and Alkali Lakes.

118. Waring, G. A., Geology and water resources of the Harney Basin region, Oregon: U. S. Geol. Survey Water-Supply Paper 231, pp. 35–41, 1909. Contains data on several warm and hot springs.

119. Stearns, H. T., Water supply of McKenzie Valley, Oreg.: U. S. Geol. Survey Water-Supply Paper 597, p. 181, 1929. Describes Belknap Hot Springs.

SOUTH DAKOTA

120. Darton, N. H., Preliminary description of the geology and water resources of the southern half of the Black Hills and adjoining regions in South Dakota and Wyoming: U. S. Geol. Survey 21st Ann. Rept., pt. 4, p. 575, 1901. Mentions hot springs at Hot Springs (town) and Hot Brook, 3 miles to the west, issuing from axis of anticline.

121. Darton, N. H., and Smith, W. S. T., U. S. Geol. Survey Geol. Atlas, Edgemont folio (no. 108), p. 9, 1904. Describe Cascade Springs and give analysis of the water.

122. Darton, N. H., Artesian waters in the vicinity of the Black Hills, S. Dak.: U. S. Geol. Survey Water-Supply Paper 428, pp. 28, 54, 1918. Mentions Hot Springs, 45° warmer than the mean annual temperature; Cascade Springs, tepid; and warm springs in Buffalo Gap.

UTAH

[See also references 39, 84, 105, and 141]

123. Gilbert, G. K., Lake Bonneville: U. S. Geol. Survey Mon. 1, pp. 333, 349, 350, 1890. Mentions hot springs at Fumarole Butte and in North Ogden Canyon.

124. Richardson, G. B., Underground water in the valleys of Utah Lake and Jordan River, Utah: U. S. Geol. Survey Water-Supply Paper 157, pp. 29–55, 1906. Comments on the remarkable series of thermal springs along the great

fault at the west base of the Wasatch Mountains. Analyses show abundant salts, chiefly chlorides with minor sulphates and carbonates, and some contain much hydrogen sulphide. Mentions thermal springs in and near Salt Lake City and near each end of Utah Lake.

125. Richardson, G. B., Underground water in Sanpete and central Sevier Valleys, Utah: U. S. Geol. Survey Water-Supply Paper 199, pp. 25, 35, 36, 58, 1907. Gives data on warm and hot springs in the area; states that 30 fault springs discharge a total of 95 second-feet of water.

126. Lee, W. T., Water resources of Beaver Valley, Utah: U. S. Geol. Survey Water-Supply Paper 217, pp. 19, 20, 21, 45, 50, 1908. Describes warm springs at Sulphurdale, McKean's Hot Spring, Dotson's Spring, and warm springs near Thermo, and gives analyses.

127. Meinzer, O. E., Ground water in Juab, Millard, and Iron Counties, Utah: U. S. Geol. Survey Water-Supply Paper 277, pp. 43, 129, 131, 133, 1911. Gives data on several thermal springs in the area.

128. Carpenter, Everett, Ground water in Box Elder and Tooele Counties, Utah: U. S. Geol. Survey Water-Supply Paper 333, pp. 30, 42, 66, 1913. Describes four hot springs in lower Bear River Valley, all near faults; and a warm spring in sec. 20, T. 12 N., R. 15 W.; Blue Springs are shown on map (pl. 1).

129. Bryan, Kirk, Classification of springs: Jour. Geology, vol. 27, pp. 522–561, 1919. Describes and gives map of Fish Springs area, Utah, three hot-spring groups along a fault, with recent fault scarp in alluvium; Devil's Hole 7 miles to the south, is probably the last survivor of another group of fault springs whose water is now diverted into alluvium and rises (cool) in Cone Springs, to the east, down the slope.

130. Pack, F. J., Geology of Weber County, Utah: Utah Univ. Bull., vol. 11, no. 19, pp. 26, 27, 1921. Gives data on Utah Hot Springs and Ogden Hot Springs; considers the water to be magmatic.

131. Pack, F. J., Structure of thermal springs on the Wasatch fault: Am. Jour. Sci., 5th ser., vol. 14, pp. 409–418, 1927. Describes Wasatch fault extending 150 miles southward from Idaho line with maximum displacement 10,000 feet; four major thermal-spring groups along it (Honeyville Hot Spring, Utah and Ogden Hot Springs, Beck's Hot Spring, Crystal Lake Spring). All are in topographic low positions, three being at the bases of mountain spurs. Wells drilled near Beck's Spring affected its flow, and a drainage canal 1 mile distant caused it to cease flowing until pressure was restored by impounding part of the canal where cool springs issued.

VIRGINIA

[See also reference 56]

132. Rogers, W. B., A reprint of the annual reports and other papers on the geology of the Virginias, by the late William Barton Rogers, 832 pp., New York, 1884. "Analyses of the waters of the principal mineral springs of Virginia" (pp. 549–564) includes analyses of the following thermal springs: In Virginia, Sweet Springs (New Red and Old Red), Alleghany County; Hot Springs and Warm Springs, Bath County; Wilson's Thermal Springs, Botetourt County; McHenry's Thermal Spring, Scott County; and in West Virginia, White Sulphur Springs, Greenbrier County; and Sweet Springs, Monroe County. "Connection of thermal springs in Virginia with anticlinal axes and faults" (pp. 575–597) (reprinted from Assoc. Am. Geologists Trans., 1840–42), shows that the springs are closely related to the structure; lists 56 springs (23 of which have temperatures less than 65°), at 29 localities in Virginia and West Virginia.

133. Reeves, Frank, Thermal springs of Virginia: Virginia Geol. Survey Bull. 36, 56 pp., 1932. Lists and gives data on 321 springs in the area and mentions several others; about 85 in Virginia and West Virginia have temperatures of 55°

or higher; considers the water to be derived from rainfall, penetrating to sufficient depths to become heated, and rising by hydrostatic head, along faults or anticlinal axes.

WASHINGTON

134. Smith, G. O., Geology and water resources of a portion of Yakima County, Wash.: U. S. Geol. Survey Water-Supply Paper 55, p. 45, 1901. Describes Clerf Spring, probably rising from sandstone beneath basalt. The natural flow was increased fourfold by excavating.

135. Plummer, F. G., Forest conditions in the Cascade Range, Wash., between the Washington and Mount Rainier Forest Reserves: U. S. Geol. Survey Prof. Paper 6, pp. 37, 38, 1902. Describes the springs at Hot Springs; mentions other thermal springs near the Middle Fork of the Snoqualmie River and on the North Fork of the Skykomish River, and hot sulphur springs at Madison.

136. Smith, G. O., U. S. Geol. Survey Geol. Atlas, Ellensburg folio (no. 86), p. 7, 1903. Mentions Clerf Spring, rising from sandstone beneath basalt.

137. Landes, Henry, Preliminary report on the underground waters of Washington: U. S. Geol. Survey Water-Supply Paper 111, pp. 26, 31, 44, 65, 1905. Describes Great Northern Hot Springs near Madiscn; warm spring issuing from basalt in T. 6 N., R. 13. E.; hot springs on the Big Klickitat River (Blockhouse Hot Springs); hot springs in sec. 16, T. 2 N., R. 7 E.; and warm springs on Yakima Indian Reservation (carbonated and deposit iron-stained tufa).

138. Calkins, F. C., Geology and water resources of a portion of east-central Washington: U. S. Geol. Survey Water-Supply Paper 118, p. 56, 1905. Describes Clerf Spring as a natural artesian well in the Ellensburg formation overlying basalt, the natural flow having been increased fourfold by excavation.

139. Waring, G. A., Geology and water resources of a portion of south-central Washington: U. S. Geol. Survey Water-Supply Paper 316, pp. 29, 46, 1913. Gives data on Nicolai Spring, 10 miles north of Sunnyside.

WEST VIRGINIA

[See also references 132 and 133]

140. Stose, G. W., and Martin, G. C., Water resources of the Pawpaw and Hancock quadrangles, West Virginia, Maryland, and Pennsylvania: U. S. Geol. Survey Water-Supply Paper 145, p. 60, 1905. State that Berkeley Springs, W. Va., issue at the base of a monoclinal ridge of Oriskany sandstone; water at 73° probably rises from depth of 1,000 to 1,300 feet; give analysis and description of springs.

WYOMING

[See also references 57 and 65]

141. Hayden, F. V., U. S. Geol. Survey Terr. 6th Ann. Rept., for 1872, 1873. Contains descriptions of thermal springs, as follows: By A. C. Peale, springs in Yellowstone National Park (pp. 122–158); list of thermal springs, including about 55 groups in Yellowstone region, 1 each in Colorado, Idaho, and Montana, and 3 in Utah (pp. 175–178); by F. H. Bradley, hot springs near Salt Lake City (p. 198); a strongly saline group of hot springs 12 miles north of Brigham City (p. 199); a small warm spring on tufa mound 1 mile south of Malad City (p. 201); springs and geysers in Yellowstone Park (pp. 230–241); hot springs that deposit tufa just below Hobacks, Idaho (p. 268); The Washtub, about 3 miles below mouth of the Salt River, and group of warm springs near Caribou mines (p. 269); small hot spring on the north bank of the Snake River 4 miles below the Salt River (p. 271).

142. St. John, Orestes, U. S. Geol. and Geog. Survey Terr. 12th Ann. Rept., for 1878, pt. 1, p. 267, 1883. Describes springs on Warm Spring Creek, Wind River Basin, with large deposits of tufa at present springs, and tufa of extinct springs 2 miles downstream and 250 feet above the creek.

143. Peale, A. C., U. S. Geol. and Geog. Survey Terr. 12th Ann. Rept., for 1878, pt. 2, pp. 63–454, 1883. Description of springs and geysers of Yellowstone National Park (pp. 65–303); thermal springs and geysers, including a table of thermal springs of the United States (pp. 304–354); thermo-hydrology (pp. 355–426); bibliographic appendix (pp. 427–454).

144. Gooch, F. A., and Whitfield, J. E., Analyses of waters of the Yellowstone National Park: U. S. Geol. Survey Bull. 47, 84 pp., 1888. Give methods of analysis and analyses of 38 waters, including several geysers and hot springs.

145. Weed, W. H., Formation of travertine and siliceous sinter by the vegetation of hot springs: U. S. Geol. Survey 9th Ann. Rept., pp. 613–676, 1889. Describes deposits at Mammoth Hot Springs and in Upper Geyser Basin. Concludes that plant life of the calcium-bearing Mammoth Hot Springs causes deposit of tufa; vegetation of the hot alkaline waters in Upper Geyser Basin causes siliceous deposit; the thickness and extent of these deposits make the plant life an important geologic agent.

146. Eldridge, G. H., A geological reconnaissance in northwest Wyoming: U. S. Geol. Survey Bull. 119, pp. 67, 68, 1894. Mentions Striking Water Springs, of warm sulphureted water, with extensive tufa deposits; Big Horn Hot Springs, on the axis of an anticline in Triassic red beds; and Fort Washakie Hot Spring, on the axis of another anticline.

147. Hague, Arnold, Weed, W. H., and Iddings, J. F., U. S. Geol. Survey Geol. Atlas, Yellowstone National Park folio (no. 30), 1896. Contains a summary of the hot springs and their deposits and views of several of the most noted springs and geysers.

148. Hague, Arnold, and others, Geology of the Yellowstone National Park: U. S. Geol. Survey Mon. 32, pt. 2, Descriptive geology, petrography and paleontology, accompanied by atlas of 27 folio sheets, 1904. The atlas sheets include six detailed topographic maps showing the springs and geysers in Mammoth Hot Spring area and in Norris, Firehole, Excelsior, Upper, and Shoshone geyser basins.

149. Darton, N. H., The hot springs at Thermopolis, Wyo.: Jour. Geology, vol. 14, pp. 194–200, 1906. Describes the geology and structure and gives analysis of the water.

150. Darton, N. H., Geology of the Owl Creek Mountains, Wyo.: 59th Cong., 1st sess., S. Doc. 219, 48 pp., 1906. Describes (p. 39) the geology at Thermopolis Hot Springs, and gives analysis of the water.

151. Fisher, C. A., Mineral resources of the Bighorn Basin: U. S. Geol. Survey Bull. 285, pp. 311–315, 1906. Describes (pp. 314–315) Cody Hot Springs and Thermopolis Hot Springs, and gives analysis of the latter.

152. Fisher, C. A., Geology and water resources of the Bighorn Basin, Wyo.: U. S. Geol. Survey Prof. Paper 53, pp. 61, 62, 1906. States that Cody Hot Springs rise from sandstone at the base of the Deadwood formation, possibly from a depth of 2,200 feet. Gives analysis of water at Thermopolis Hot Springs and mentions several others.

153. Woodruff, E. G., Sulphur deposits at Cody, Wyo.: U. S. Geol. Survey Bull. 340, pp. 451–456, 1907. Mentions springs in Shoshone Canyon (98°); much hydrogen sulphide and carbon dioxide.

154. Woodruff, E. G., Sulphur deposits near Thermopolis, Wyo.: U. S. Geol. Survey Bull. 380, pp. 373–380, 1909. Gives detailed description of hot springs near Thermopolis.

155. Schlundt, Herman, and Moore, R. B., Radioactivity of the thermal waters of Yellowstone National Park: U. S. Geol. Survey Bull. 395, 35 pp., 1909. Discuss the methods used and the results. They found the adjacent rocks as well as the waters and gases to be radioactive.

156. Hague, Arnold, The origin of the thermal springs in the Yellowstone National Park: Geol. Soc. America Bull., vol. 22, pp. 103–122, 1911. Annual address of the president, Dec. 27, 1910. (1) Igneous activity extended throughout the Tertiary period; (2) it ended at the close of the Pliocene; (3) during Eocene-Miocene time deep-seated waters were geologic agents; (4) Pliocene lavas issued quietly and built up the rhyolite plateau; (5) these lavas were altered by enormous amounts of heated vadose water; (6) the gases in the water are vadose; (7) geyser phenomena are from shallow depth; (8) present phenomena are a phase in the evolution of thermal springs.

157. Hague, Arnold, Origin of the thermal waters in the Yellowstone National Park: Science, new ser., vol. 33, pp. 553–568, 1911. Nearly the same as reference 156.

158. Hares, C. J., Anticlines in central Wyoming: U. S. Geol. Survey Bull. 641, pp. 233–279, 1917. Mentions (p. 236) a large warm spring in sec. 35, T. 32 N., R. 86 W.; hot mineral water in gorge just above Alcova; Big Sulphur Springs in sec. 5, T. 38 N., R. 83 W.; warm water in Beaver Gorge, 5 miles above Hailey; and warm springs in T. 29 N., R. 95 W.

159. Hewett, D. F., and Lupton, C. T., Anticlines in the southern part of the Big Horn Basin, Wyo.: U. S. Geol. Survey Bull. 656, p. 136, 1917. State that the town of Thermopolis and the hot springs (included in a State reservation) are on the south flank of the Thermopolis anticline.

160. Collier, A. J., Oil in the Warm Springs and Hamilton domes, near Thermopolis, Wyo.: U. S. Geol. Survey Bull. 711, pp. 61–73, 1920. Mentions (p. 61) the occurrence of hot springs near the axis of the Thermopolis anticline.

161. Van Orstrand, C. E., Temperatures in some springs and geysers in Yellowstone National Park: Jour. Geology, vol. 32, pp. 194–225, 1924. Gives temperatures of about 140 springs and geysers.

162. Bartlett, A. B., The mineral hot springs of Wyoming: Wyoming State Geologist's Office Bull. 19, 15 pp., 1926. Describes nine thermal springs in the State outside of Yellowstone National Park; gives analyses of Big Horn, Saratoga, Alcova, Fort Washakie, and Demaris Hot Springs.

162a. Allen, E. T., and Day, A. L., Hot springs of the Yellowstone National Park (microscopic examinations by H. E. Merwin): Carnegie Inst. Washington Pub. 466, 1936. A comprehensive and critical study of the springs of the park with special reference to the origin of the water and heat and the diversity in chemical character of the water. Includes many analyses.

GENERAL

[See also reference 143]

163. Bell, John, The mineral and thermal springs of the United States and Canada, 394 pp., Philadelphia, 1855. A discourse on the medical use of the waters, and description of springs by States; lists 32 thermal springs of the United States (includes springs at Bennington, Vt., springs of Florida; and spring on French Broad River, Tenn.).

164. Moorman, J. J., Mineral springs of North America, how to reach and how to use them, 1st ed., 294 pp., Philadelphia, 1871. An earlier work was published as "Mineral waters of the United States and Canada", 507 pp., 1867. Gives medical discussion of use followed by detailed discussion of springs of Virginia and West Virginia; then descriptions, partly taken from Bell's work, of springs and resorts in other States; lists (p. 284), 29 thermal springs.

165. Walton, G. E., Mineral springs of the United States and Canada, 1st ed. 390 pp., 1873; 2d ed., 1874; 3d ed., 468 pp., 1883. After preliminary medical discussion of use describes mineral springs under the groupings saline, sulphur, chalybeate, purgative, calcic, thermal, and unclassified. Under thermal springs, describes 24 spring localities as follows: Arkansas: Hot Springs; California: Calistoga, Geysers, Paso Robles, Santa Barbara, Warners Ranch, San Bernardino, Skaggs, Gilroy, and Lake Tahoe; Colorado: Idaho Springs and Middle Park; Georgia: Warm Springs; North Carolina: Warm Springs; New Mexico: Agua Caliente (Mesilla County); New York: Lebanon Spring; Nevada: Pueblo Hot Springs, and Volcano Hot Springs (Lander County); Oregon: Deschutes Springs; Utah: Salt Lake City Warm Springs; Virginia: Hot Springs, Warm Springs, and Healing Springs; Wyoming: American Geysers.

166. U. S. Geog. and Geol. Surveys W. 100th Mer. Rept., vol. 3, 1875. In part 1, by G. K. Gilbert, figure 3 (opposite p. 148) is a map of the United States, showing hot springs. "So far as temperatures are definitely known, only those are included which exceed the mean annual temperature of the air by 15° F." (p. 149). Table of thermal springs of the United States (pp. 150–153) lists 136 spring localities. Speaks of extensive tufa deposits, with many warm springs, near Medway, on the Provo River, Utah, and spring at 185° in Escalante Valley, 16 miles west of Minersville (pp. 256–257). A chapter on mineral springs, by John J. Stevenson (pp. 478–487) describes Pagosa Springs, Mound Soda Spring, sulphur springs in South Park, and Idaho Springs, Colo. A chapter on analyses of mineral springs and minerals, by Oscar Loew (pp. 613–627), describes 12 other thermal springs in Colorado and New Mexico, with analyses of Ojo Caliente (Taos County, N. Mex.); hot springs on Rio San Francisco 7 miles above its junction with Gila River, N. Mex.; and Pagosa Springs, Colo. Plate 13 (p. 616) is a detailed map of Ojo Caliente Springs, N. Mex.

167. Clarke, F. W., and Chatard, T. M., A report of work done in the Washington laboratory during the fiscal year 1883–84: U. S. Geol. Survey Bull. 9, pp. 24–35, 1884. Contains 15 analyses of thermal springs, as follows: Nevada: Hot springs at foot of Granite Mountain (Ward's ranch) and at Hot Springs station (Central Pacific R. R.); California: Warm spring in Mono Basin, and boiling spring in Honey Lake Valley, 4 miles southeast of Shaffer's ranch; Utah: Utah Hot Springs, 8 miles north of Ogden; Montana: Livingston warm springs, warm spring in Emigrant Gulch, and Helena Hot Springs; Virginia: Six springs at Hot Springs.

168. Bell, A. N., Climatology and mineral waters of the United States, 386 pp., New York, 1885. Chapters 1–14 (pp. 1–143) and 19–22 (pp. 251–379) treat of climatology and factors related to it. Chapters 15–18 (pp. 144–249) treat of the climatology and mineral springs of the Atlantic States, Mississippi Basin, western highlands, and Pacific slope. About 175 springs are described or mentioned, of which 30 are at thermal-spring resorts.

169. Peale, A. C., Lists and analyses of the mineral springs of the United States: U. S. Geol. Survey Bull. 32, 235 pp., 1886. Gives descriptions by States, with tabulated data on discharge and temperature. Lists 2,822 mineral-spring localities, including many thermal springs, and gives 859 analyses.

170. Peale, A. C., Natural mineral waters of the United States: U. S. Geol. Survey 14th Ann. Rept., pt. 2, pp. 48–88, 1894. Gives general discussion of thermal springs (pp. 68–69) and a list, by States, of about 640 mineral-spring resorts including many thermal springs (pp. 81–88).

171. Crook, J. K., Mineral waters of the United States and their therapeutic uses, 588 pp., Philadelphia, 1899. Part 1 (pp. 1–83) discusses the medical use of mineral waters. Part 2 (pp. 84–553) describes by States about 490 mineral-water localities (most of which are cool springs and some of which are wells),

with data on their development as resorts, and gives analyses taken from various sources. Also mentions, under some of the States, springs concerning which definite information was not obtained.

172. Haywood, J. K., Mineral waters of the United States: U. S. Dept. Agr. Bur. Chemistry Bull. 91, 100 pp., 1905. Gives 65 analyses, chiefly of commercial waters, but contains analyses of Healing Springs and Rockbridge Alum Springs, Va.

173. Fitch, W. E., Mineral waters of the United States and American spas, 799 pp., Philadelphia, 1927. The first 13 chapters (pp. 1–200) discuss the sources of mineralization, classification of mineral waters, radioactivity, and therapeutic use. Chapter 14 (pp. 201–712) describes the mineral springs by States, about 400 receiving individual discussion, of which about 75 are thermal-spring resorts. Analyses from various sources are included. Chapter 15 (pp. 713–755) describes Hot Springs, Ark.; Manitou, Colo. (nonthermal); Hot Springs, S. Dak.; and White Sulphur Springs, W. Va.

UNPUBLISHED INFORMATION

174. Data in the files of the United States Geological Survey, including information furnished by the Forest Service, Indian Service, and General Land Office.

TABULATED DATA

Statistical data on thermal springs are presented in the following table. The locations of the springs are shown by numbers on the maps indicated under each State.

Data on thermal springs in the United States

Arizona

[See pl. 13]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Mohave County						
1	Tributary of Grand Wash, 18 miles north of Colorado River.	Pakoon Spring	Late Tertiary lava	100		143, p. 325; 166, p. 152.	Not used. Also spelled Pahgun.
2	Colorado River, 5 miles south of Boulder Dam, sec. 23, T. 30 N., R. 23 E.	(2)	Tertiary lava	Hot		174	Not used.
2a	Grand Canyon of Colorado River, near Lava Falls Rapids.	Lava Springs	Fault exposing granite beneath ancient sedimentary rocks.	89	6,700	166, p. 155; 169, p. 196.	Several springs; not used.
2b	25 miles southwest of Kingman, sec. 33, T. 18 N., R. 19 W.	(2)	Tertiary lava	Warm		174	Not used.
	Yavapai County						
3	10 miles northeast of Camp Verde, sec. 32, T. 15 N., R. 6 E.		Lower Permian rocks overlain by Tertiary lava.	72	50	174	3 springs; local use.
4	½ mile northwest of Childs	Verde Hot Springs	Tertiary lava	104	75	174	Several springs; resort.
5	Castle Creek, 50 miles south of Prescott, sec. 3, T. 7. N., R 1 W.	Castle Hot Springs	do	115–122	280	169, p. 196; 171, p. 96*; 173, p. 228*.	2 springs; formerly Monroe Hot Springs; resort; bathing.
	Apache County						
6	6 miles south of St. Johns		Triassic sandstone	74	2	174	Not used; tufa deposits.
	Gila County						
7	23 miles west of Whiteriver, sec. 13, T. 6 N., R. 19 E., Fort Apache Indian Reservation.	Soda Spring	Limestone in Supai formation.	65		174	Local use.
8	30 miles west of Whiteriver, about sec. 33, T. 6 N., R. 17 E., Fort Apache Indian Reservation.	Salt Banks	Cambrian sandstone	Warm		174	Large group of springs; local use.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.
[2] Not shown on pl. 8.

Data on thermal springs in the United States—Continued

Arizona—Continued

[See pl. 13]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Maricopa County						
9	15 miles northeast of Palomas, sec. 19, T. 5 S., R. 10 W.	Agua Caliente Springs	Quaternary lava	99-104		3, pp. 197, 198*; 173, p. 227*.	Several springs; resort.
	Graham County						
10	3 miles north of Aravaipa, sec. 35, T. 5 S., R. 19 E.		Tertiary lava	90	6	174	1 spring; bathing.
11	Gila River, 3 miles north of Fort Thomas.		Pliocene lake beds			174	Do.
12	8 miles northwest of Pima, southeast of Fort Thomas.	Indian Hot Springs	do	81-118	300	5a*, 174	5 springs and 1 well, 600 feet deep; resort.
13	Bonito Creek, 25 miles east of Fort Thomas, T. 4 S., R. 27 E.		Tertiary lava	Warm		174	1 spring; not used.
	Greenlee County						
14	Near Eagle Creek, 10 miles west of Morenci, T. 4 S., R 28 E.		do	Hot	Small	1, p. 13	Do.
15	Clifton	Clifton Hot Springs	do	127-160		1, p. 13*; 5, p. 291; 173, p. 229*.	4 springs; resort.
	Pima County						
16	Quitobaquito, close to Mexican boundary.	Aguajito Spring	Alluvium, near hills of schist	Warm		4, p. 164	Village water supply; irrigation.
	Santa Cruz County						
17	5 miles east of Amado, sec. 13, T. 20 S., R. 13 E.	Agua Caliente Spring	Issues from red shale and sandstone (Cretaceous?) through overlying Quaternary gravel.	90	50	2, p. 366; 166, p. 152.	Bathing; used since earliest settlement.
	Cochise County						
18	10 miles northeast of Cascabel, sec. 6, T. 13 S., R. 21 E.	Hookers Hot Springs	Granitic rocks; faulted	130	40	174	2 main springs; bathing.
19	6 miles southwest of Paradise, sec. 7, T. 18 S., R. 31 E.		Quartzite dike near Tertiary lava.	67	225	174	1 spring; local use.

Arkansas

[See pl. 8]

	Randolph County						
1	Mud Creek	Rice's Spring	Ordovician limestone	82		169, p. 121	Resort.
	Montgomery County						
2	Little Missouri River, sec. 17, T. 4 S., R. 27 W.		Arkansas novaculite	74		11, p. 429	1 spring; not used.
3	Bed of Caddo River at Caddo Gap, sec. 19, T. 4 S., R. 24 W.		do	96–100		10, p. 285; 11, p. 429.	Several springs; not used.
	Pike County						
4	Redland Mountain, sec. 12, T. 5 S., R. 26 W.		do	77		11, p. 429	1 spring; not used.
	Garland County						
5	Hot Springs	Hot Springs	Water rises from Hot Springs sandstone (Pennsylvanian) overlying Arkansas novaculite; issues at end of plunging anticline.	102–147	165	6, pp. 6–23; 7, pp. 1–78; 8, pp. 128–132; 9, p. 189*; 10 pp. 278–285; 11, pp. 425–449; 12, p. 11; 13, pp. 449–459; 173, pp. 218–222* and 713.	46 thermal springs in area of 20 acres; resort; Hot Springs National Park; sanitariums Army and Navy General Hospital.
6	5½ miles northeast of Hot Springs	Big Chalybeate Spring	Rises from Paleozoic rocks	79	185	11, p. 429	Local use.

California

[See pl. 15]

	Siskiyou County						
1	14 miles southeast of Happy Camp, sec. 29, T. 15 N., R. 8 E.		Granite	90	2	174	1 spring; bathing.
2	20 miles northeast of Ager	Klamath Hot Springs	Local fracturing and fault in lava.	100–152	25	23, pp. 120–121*	7 springs; resort. Formerly Shovel Creek Springs.
3	Mount Shasta, 11 miles northeast of Sisson.		Tertiary lava	150	5	23, p. 144	2 springs; not used.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

Data on thermal springs in the United States—Continued

California—Continued

[See pl. 15]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Modoc County						
4	35 miles northwest of Alturas	Pothole Spring	Lava	70	10	23, p. 334	Not used.
5	Near Rattlesnake Creek, 9 miles west of Alturas.		do	80	10	23, p. 120	1 spring; not used.
6	Hot Creek, 9 miles west of Alturas, sec. 10, T. 42 N., R. 11 E.	Essex Springs	do	80–92	700	23, p. 119	5 springs; bathing, irrigation.
7	Warm Spring Valley, 15 miles west of Alturas.		do	81	275	23, pp. 119–120*	1 spring; domestic, irrigation.
8	4 miles northeast of Canby, sec. 29, T. 42 N., R. 10 E.	Kelly's Hot Spring	Alluvium; faulted area	204	325	23, p. 118	Domestic, irrigation.
9	Near Canyon Creek, 15 miles southwest of Alturas.		Probable faults in lava	80	100	23, p. 120	1 spring; domestic, irrigation.
10	1½ miles southeast of Alturas		Lava underlying valley alluvium.	72	1	23, p. 323	1 spring; cattle watering.
11	Little Hot Spring Valley, 25 miles northwest of Bieber.		Base of low basaltic slopes	127, 170	225	23, p. 118	2 springs; irrigation.
12	Bidwell Creek, 1 mile west of north of Fort Bidwell.		Base of lava slopes, faults	97–108	75	23, p. 121	5 springs; domestic, bathing, irrigation.
13	East side of Upper Lake, 12 miles east of south of Fort Bidwell.	Boyd Spring	Alluvium	70	1,000	23, p. 124	Irrigation.
14	Near southwest side of Upper Lake, 12 miles north of Cedarville.		Alluvium; faulted area	120	5	23, p. 122	1 spring; not used. Artesian wells in vicinity yield hot water.
15	East border of Surprise Valley, 12 miles northeast of Cedarville.		Near ledge of iron-stained, silicified rock, probably an andesitic dike. Faulted area.	170–182	80	23, p. 123	4 springs; sheep dipping.
16	East side of Surprise Valley, 12 miles northeast of Cedarville, sec. 12, T. 43, N., R. 18 E.		Alluvium; fault	140–149	225	23, p. 123	3 springs; irrigation.
17	11 miles northeast of Cedarville, sec. 7, T. 43 N., R. 17 E.	Leonard Springs	do	150	50	174	3 springs; local use.

18	5 miles north of east of Cedarville, sec. 1, T. 42 N., R. 16 E., and sec. 6, T. 42 N., R. 17 E.		Alluvium; faulted area	130	500	174	5 principal springs, not used; 2 wells ½ mile north, discharge 115 gallons per minute of boiling water; bathing, sanitarium.
19	Near east side of Middle Lake, 5 miles east of Cedarville, sec. 18, T. 42 N., R. 17 E.	Benmac Hot Springs	do	120	200	23, p. 123; 174	1 spring; irrigation.
20	Near west side of Lower Lake, 5 miles east of south of Eagleville, sec. 7, T. 39 N., R. 17 E.	Menlo Warm Springs	Gravel of valley side. Faults.	117–125	425	23, p. 123	5 springs; irrigation, bathing.
21	Near southwest side of Lower Lake, 8 miles east of south of Eagleville.		Faults in lava	120	100	23, p. 123	1 spring; irrigation.
22	South end of Surprise Valley, 12 miles east of south of Eagleville.		Fault, or artesian structure in alluvium.	70	5	23, p. 124	1 spring; not used.
	Shasta County						
23	Kosk Creek, 65 miles northeast of Redding.		Porphyritic quartz diorite intruded into old sediments. Lava flows and local faulting.	100	5	23, p. 116	2 springs; not used.
24	63 miles northeast of Redding, sec. 36, T. 37 N., R. 1 W.	Big Bend Hot Springs	Gravel; porphyritic quartz diorite intruded into old sediments. Lava flows and local faulting.	100–180	90	23, p. 115	6 springs; resort.
25	Upper Mill Creek, 1 mile northwest of Tophet Hot Springs.		Lava of Lassen Peak area	120–150	3	31, p. 98	3 springs; not used.
26	Southwest side of Lassen Peak, 53 miles northeast of Red Bluff.	Tophet Hot Springs	do	(2a)	5	23, p. 141; 30, pp. 178–190; 31, p. 96.	About 10 springs and mud pots; not used. Deposits of sulphur. Also called Soupan or Supan Hot Springs.
27	South side of Lassen Peak, 60 miles northeast of Red Bluff.	Bumpas Hot Springs	do	Boiling	100	23, p. 140; 31, p. 94	About 20 springs; not used. Called also Bumpas Hell.
	Lassen County						
28	2½ miles north of east of Bieber	Bassett Hot Springs	Fissure in tuffaceous sandstone.	173	175	23, p. 117*	Bathing; irrigation.
29	6 miles south of east of Bieber	Stonebreaker Hot Springs	Tuffaceous sandstone underlying meadow alluvium.	110–165	125	23, p. 117	9 springs; irrigation.
30	Near north shore of Honey Lake, ¾ mile southwest of Hot Springs station.	Shaffer Hot Springs	Alluvium; calcareous tufa; probable faults.	160–204 [3]	250	15, p. 51; 23, pp. 124–126*.	3 springs; bathing; formerly Branbecks Hot Springs.
31	Near Amedee railroad station	Amedee Hot Springs	Alluvium, and some deposits of calcareous tufa.	178–204 [3]	700	15, p. 51; 23, p. 127*.	7 springs; bathing.
32	10 miles south of east of Amedee	Highrock Spring	Tertiary basaltic lava	86	525	23, p. 128	Domestic, irrigation.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.
[2a] 175° to boiling.
[3] Boiling.

Data on thermal springs in the United States—Continued

California—Continued

[See pl. 15]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Tehama County						
33	53 miles northeast of Red Bluff	Morgan Hot Springs	Lava of Lassen Peak area	90–200	85	23, pp. 138–139 and 142*; 31, p. 98.	26 springs; camping ground.
	Plumas County						
34	72 miles northeast of Red Bluff, 1½ miles west of Drake Hot Springs.	Devils Kitchen	Lava altered by solfataric action.	150–205 [3]	50	23, pp. 141–142*; 31, p. 91.	About 30 springs; not used.
35	Hot Spring Valley, 70 miles northeast of Red Bluff, ½ mile west of Drake Hot Springs.		Lava of Lassen Peak area	83	8	23, p. 227	1 spring; drinking; carbonated.
36	70 miles northeast of Red Bluff, 6 miles southeast of Lassen Peak.	Drake Hot Springs	do	123–148	20	23, p. 142; 31, p. 90.	4 springs; resort.
37	69 miles northeast of Red Bluff, 1 mile south of Drake Hot Springs.	Boiling Spring Lake	do	170–190	(4)	23, p. 143; 31, p. 88.	10 springs; not used; also called Tartarus Lake.
38	66 miles northeast of Red Bluff, 3½ miles southeast of Drake Hot Springs.	Terminal Geyser	do	120–205 [3]	8	23, p. 143; 31, p. 88.	6 springs; not used.
39	1 mile east of Greenville	Kruger Springs	Artesian structure and possible fault in alluvium.	90–106	8	23, p. 128	5 springs; bathing.
40	2 miles northeast of Twain, sec. 13, T. 25 N., R. 8 E.		Carboniferous slate	94	20	174	1 spring; not used.
41	Indian Creek, 1 mile east of Twain, sec. 24, T. 25 N., R. 8. E.		do	80–98	35	174	7 springs; not used.
42	5 miles southwest of Beckwith	McLear Sulphur Springs	Lake sediments; beneath tuffaceous agglomerate.	86	140	18, p. 390, 396; 23, p. 283.	8 springs; domestic, irrigation.
	Sierra County						
43	2 miles south of Sierraville	Campbell Hot Springs	Faulted andesite lava	65–111	80	23, pp. 129–130	11 springs; resort.
	Placer County						
44	13 miles southeast of Truckee, 10 miles northeast of Tahoe, on north shore of Lake Tahoe.	Brockway Hot Springs	Probable fault in granodiorite overlain by andesitic lava.	120–140	150	23, p. 131; 143, p. 326; 173, pp. 238–239*.	6 springs; resort

	Mendocino County						
45	16 miles northwest of Ukiah	Orrs Hot Springs	Franciscan formation of crushed sandstone with chert and serpentine; faults subsidiary to San Andreas rift.	63-104	25	23, p. 83	7 springs; resort.
46	3 miles northeast of Ukiah	Vichy Springs	Soft sandstone and clay shales; conglomerate cemented by lime carbonate deposited from spring water.	59-90	30	23, pp. 171-173*	Do.
47	15 miles southeast of Point Arena	Point Arena Hot Springs	Basaltic lava	110-112	4½	23, p. 82	2 springs; resort.
	Lake County						
48	38 miles east of north of Lakeport	Crabtree Springs	Siliceous rock closely associated with serpentine; also altered shale and sandstone.	68-105	15	23, p. 106	4 springs; camping ground.
49	2 miles northwest of Bartlett Springs, sec. 35, T. 16 N., R. 8 W.		Serpentine in Franciscan formation (Jurassic?).	90	5	174	1 spring; bathing.
50	45 miles west of Williams	Newman Springs	Issue at base of serpentine ledge, at contact with crumpled shale and siliceous sediments.	70-92	25	23, p. 202	9 springs; bathing; also called Soap Creek Springs.
51	28 miles west of Williams	Complexion Springs	Issue from decomposed serpentine, but altered sediments nearby.	74	1	23, pp. 297-298*	30 springs; not used.
52	6 miles southwest of Kelseyville	Highland Springs	Issue from crushed and faulted shale and sandstone.	52-82	20	23, pp. 183-185*; 173, pp. 250-252*.	11 springs; resort.
53	8 miles west of south of Kelseyville	England Springs	Crushed shale and sandstone	56-76	8	23, p. 186	7 springs; drinking; also called Elliott Springs.
54	5 miles south of Kelseyville	Carlsbad Springs	Andesite lava over thin-bedded sediments.	66-76	4	23, pp. 187-188*	4 springs; local use.
55	5 miles northeast of Kelseyville	Soda Bay Springs	Base of Mount Konocti, a lava peak.	80-87	400	23, pp. 191-192*	5 springs; resort.
56	Near southwest edge of Clear Lake, 10 miles east of Kelseyville.		Andesite of Mount Konocti, a comparatively recent lava.	70-100	5	23, p. 193	10 springs; drinking.
57	10 miles west of north of Lower Lake	Sulphur Bank Hot Springs	Basalt altered by solfataric action. Slopes near quicksilver mines, composed mainly of Lower Cretaceous rocks.	83-120		17, p. 975; 23, pp. 98-99*.	10 springs; not used.
58	28 miles west of north of Calistoga	Howard Springs	Area of serpentine within shale and sandstone.	48-110	135	23, pp. 95-96*; 173, pp. 252-253*.	26 springs; resort.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.
[3] Boiling.
[4] Intermittent.

Data on thermal springs in the United States—Continued

California—Continued

[See pl. 15]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Lake County—Continued						
59	30 miles west of north of Calistoga	Seigler Springs	Issue from serpentine. Nearby is siliceous rock, lava, and crushed sediments.	58-126	35	23, pp. 96-98*	13 springs; resort.
60	28 miles west of north of Calistoga	Gordon Hot Spring	Sediments overlain by lava and siliceous tuff.	92	5	23, p. 93*	Local use.
61	24 miles west of north of Calistoga	Spiers Springs	Crevices in serpentine; sediments nearby.	78, 84	15	23, p. 190	2 springs; bottled.
62	25 miles west of north of Calistoga	Castle Hot Springs	Hard schistose rocks	65, 164	10	23, pp. 91-93*	2 springs; resort. Formerly Mills Hot Springs.
63	22 miles west of north of Calistoga	Anderson Springs	Altered sedimentary rock with lava and schist.	63-145	7	23, pp. 89-91*	9 springs; resort.
64	20 miles west of north of Calistoga	Harbin Springs	Belt of amphibolite schist and shale, steeply dipping.	90-120	10	23, pp. 92-95*; 173, pp. 249-250*.	3 springs; resort.
	Colusa County						
65	28 miles south of west of Williams	Deadshot Springs	Serpentine in Franciscan formation (Jurassic?).	65-79	11	23, p. 195	4 springs; drinking.
66	27 miles sonthwest of Williams	Blancks Hot Springs	Sandstone, steeply dipping	120	4	20, p. 120; 23, p. 104.	2 springs; bathing.
67	26½ miles southwest of Williams	Jones Hot Springs	Area of serpentine; siliceous shales exposed across the creek to north.	125	2	20, p. 120; 23, p. 103.	Resort.
68	26 miles southwest of Williams	Wilbur Hot Springs	Country rock is serpentine with sandstone inclusions. Secondary mineralization and intense geologic action.	65-140	35	20, p. 120; 23, p. 99*; 173, p. 269.	12 springs; resort. Formerly Simmons' Hot Spring.
69	Elgin mine, 30 miles south of west of Williams.		Sandstone and associated serpentine. Quicksilver mine.	140-153	25	20, p. 120; 23, pp. 104-106*.	3 springs; not used.
	Sonoma County						
70	15 miles north of west of Cloverdale	Hoods Hot Springs	Crushed sediments. Near contact with glaucophane schist.	100	5	23, p. 82	2 springs; bathing. Formerly Fairmount Hot Springs.
71	9 miles south of west of Geyserville	Skaggs Hot Springs	Crushed and faulted sedi-	120-135	15	23, p. 81	3 springs; resort.

			mentary rocks of Franciscan formation.				
72	18 miles south of east of Cloverdale	The Geysers	Crushed and altered sandstone and shale with chert, schist, and associated serpentine of Franciscan formation; prominent fault zone. Gabbro at 230 feet in drilled well.	([5])	30-50	23, pp. 83-88*; 32, pp. 1-105; 173, pp. 242-245*.	About 30 springs; resort since 1852; bottled. Wells drilled in 1931 and later obtained steam for generating electricity.
73	Sulphur Creek, 21 miles southeast of Cloverdale.		Sandstone and shale	120	5	32, p. 94	Several springs; not used.
74	22 miles south of east of Cloverdale	Little Geysers	Cretaceous sediments	110-160	8	23, p. 88; 32, pp. 9, 95.	10 springs; camping ground.
75	7 miles northeast of Fulton	Mark West Warm Springs	Lava and tuff	60-82	30	23, p. 115	9 springs; resort.
76	3½ miles southwest of Glen Ellen	Los Guilicos Warm Springs.	Cretaceous sediments	78, 82	5	23, p. 114	2 springs; resort.
77	McEwan ranch, 3 miles southwest of Kenwood.		Lavas and tuffaceous layers; artesian structure.	80	50	23, p. 114	1 spring; irrigation.
78	State home at Eldridge, 6 miles west of north of Sonoma.		Lava under alluvium; artesian structure.	72	10	23, p. 114	Do.
79	2 miles northwest of Sonoma	Boyes Hot Springs	Lava and pre-Tertiary sediments.	114-118		23, pp. 112, 113*	1 main spring, flowed until earthquake of 1906. Wells later drilled. Resort; bottled.
	Napa County						
80	17 miles north of St. Helena	Aetna Springs	Altered sediments, opaline material, and associated serpentine of Franciscan formation. Lava to north.	63-92	20	23, pp. 156-159*	6 springs; resort; bottled.
81	⅛ mile east of Calistoga depot	Calistoga Hot Springs	Volcanic tuff. Fault in valley.	126-173	8	23, pp. 108-109*; 142, p. 326; 173, p. 245*.	4 springs; bathing. Several wells drilled in 1910-24 struck hot artesian water; used in baths.
82	2 miles southwest of St. Helena	St. Helena White Sulphur Springs.	Crushed sandstone of Franciscan formation.	59-83	6	23, pp. 254-255*	5 springs; resort.
83	15 miles north of east of St. Helena	Napa Rock Soda Springs	Altered shale and sandstone	79	15	23, p. 161*	2 springs; bottled. Also called Priest Soda Springs.
	Marin County						
84	6 miles northwest of Point Bonita	Rocky Point Spring	In pre-Tertiary sediments; oxidation of pyrite in sandstone.	100	5	23, p. 80	Not used.
	Contra Costa County						
85	2 miles northeast of Walnut Creek	Sulphur Springs	Sandstone ridge, dips nearly vertical. Intense movement, and fault along border of valley land.	75-81	5	23, p. 270	6 springs; domestic.
86	2 miles south of Byron	Byron Hot Springs	In saline flat partly enclosed by low hills of cherty gravel and other marine sediments.	72-120	15	23, pp. 109-112*; 173, pp. 240-242.	7 springs; resort.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

[5] 140° to boiling.

Data on thermal springs in the United States—Continued

California—Continued

[See pl. 15]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Alameda County						
87	2 miles northeast of Warm Springs	Warm Springs	Sandstone, gravel. Evidence of fault.	85–90	15	23, p. 80	4 springs; domestic and garden.
	Santa Clara County						
88	7 miles northwest of San Jose	Alum Rock Park Springs	Tertiary shale and sandstone; highly tilted and folded.	62–87	15	23, pp. 208–212*	17 springs; drinking, bathing. City park.
89	14 miles northeast of Gilroy	Gilroy Hot Spring	Sandstone, chert, and conglomerate; near serpentine and gabbroid rocks; probable fault.	110	15	23, pp. 79–80*	Resort; bottled.
	Monterey County						
90	North Fork of Little Sur River, 30 miles by road south of Monterey.		Local faulting in granitic area.	104	10	23, p. 57	2 springs; not used.
91	50 miles east of south of Salinas, sec. 32, T. 19 S., R. 4 E.	Tassajara Hot Springs	Gneiss; above and below is granitic material; crystalline rocks are overlain by shale, sandstone, and limestone; dips suggest area of intense pressure.	100–140	100	23, pp. 57–60*	17 springs; resort.
92	8 miles west of south of Soledad	Paraiso Hot Springs	Gravelly sandstone over granitic rocks; local fold or bedrock dam.	65–111	10	23, pp. 60–62*; 173, pp. 259–260*.	5 springs; resort.
93	63 miles east of south of Monterey, sec. 9, T. 21 S., R. 3 E.	Slate's Hot Springs	Jurassic shales overlain by gravel deposited on an ocean terrace. Water from base of gravel and from slate.	110–121	50	21, pp. 350–356; 23, p. 56.	10 springs; bathing.
94	70 miles by road east of south of Monterey.	Dolan's Hot Springs	Jurassic shale and sandstone.	100	5	23, p. 57	Not used.

	San Luis Obispo County						
95	2½ miles north of Paso Robles	Paso Robles Mud Bath Springs.	Alluvium and Tertiary sedimentary rocks.	55–118	100	23, pp. 73–75*	3 springs; bathing, bottled.
96	Southwest part of Paso Robles	Paso Robles Hot Springs	do	105	1,700	23, pp. 72–75*; 173, pp. 260–262*.	1 main spring; later developed by flowing artesian well; resort.
97	4 miles southeast of Paso Robles	Santa Ysabel Springs	Alluvium and Tertiary sedimentary rocks; probable artesian structure.	94	150	23, pp. 76–77*; 173, pp. 264–265*.	2 springs; bathing, irrigation.
98	30 miles southeast of Paso Robles	Cameta Warm Spring	Low gravel hills; fault or artesian structure.	74	3	23, p. 77	Bathing.
99	15 miles southwest of San Luis Obispo	Pecho Warm Springs	Miocene shale, locally folded and crushed.	72, 95	17	23, p. 69	2 springs; drinking, bathing.
100	2½ miles east of Arroyo Grande	Newsom's Arroyo Grande Warm Springs.	Siliceous shales; fractures associated with steep dips.	98	15	23, pp. 68–69*; 173, pp. 258–259*.	Resort.
	Santa Barbara County						
101	4 miles north of Gaviota station	Las Cruces Hot Springs	Thick-bedded sandstone, probably faulted. Ledge of calcareous material deposited by spring.	67–97	50	23, p. 68	4 springs; bathing.
102	20 miles northwest of Santa Barbara	San Marcos Hot Springs	Fractured sandstone in fault zone.	89–108	45	14, p. 192; 23, p. 67	6 springs; camping ground. Also called Mountain Glen Hot Springs and Cuyama Hot Springs.
103	6 miles northeast of Santa Barbara	Montecito Hot Springs	Issue from thick-bedded sandstone at contact of shale which overlies it.	111–118	50	22, p. 23; 23, pp. 66–67*.	11 springs; resort; part of water supply of Montecito; also called Santa Barbara Hot Springs.
104	12 miles northeast of Santa Barbara, 1 mile east of Mono Creek, sec. 4, T. 5 N., R. 25 W.		Tertiary shale	90	15	174	3 springs; not used.
105	15 miles northeast of Santa Barbara, 4 miles north of Santa Ynez River, sec. 1, T. 5 N., R. 25 W.		do	90	10	174	Do.
	Ventura County						
106	Matilija Canyon, 9 miles northwest of Nordhoff.	Vicker's Hot Springs	Tertiary sandstone and shale; crushed and probably faulted.	118	5	23, pp. 62–63*	Do.
107	8½ miles northwest of Nordhoff	Stingley's Hot Springs	Sandstone and shale; steeply inclined.	76, 100	4	23, p. 63	2 springs; domestic, bathing.
108	6 miles northwest of Nordhoff	Matilija Hot Springs	do	65–116	45	23, pp. 63–64*	4 springs; resort.
109	7½ miles west of north of Nordhoff	Wheeler's Hot Springs	do	62–102	40	23, pp. 64–66*	Do.
110	Sespe Canyon, 24 miles west of north of Fillmore, sec. 31, T. 6 N., R. 20 W.	Willett Hot Spring	Tertiary shale	120	50	174	Bathing.
111	Sespe Canyon, 22 miles west of north of Fillmore, sec. 21, T. 6 N., R. 20 W.	Sespe Hot Springs	Granitic rock beneath crushed shale; faulted.	97–191	125	14, p. 199; 23, p. 66	4 springs; camping ground.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

Data on thermal springs in the United States—Continued

California—Continued

[See pl. 15]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Los Angeles County						
112	Elizabeth Lake Canyon, 13 miles east of north of Castac station.		Subsidiary fracturing; San Andreas fault is 8 miles north.	100	5	23, p. 66	1 spring; not used.
	Alpine County						
113	4 miles west of Markleeville	Grover's Hot Springs	Granite; lava less than ½ mile to east; near southern extension of Sierra Valley fault.	128–146	100	23, p. 131	12 springs; camping ground.
	Mono County						
114	13 miles northwest of Bridgeport, sec. 24, T. 6 N., R. 23 E.	Fales' Hot Springs	Higher slopes granitic, but slopes nearby are lava.	97–141	300	23, p. 132	2 springs; resort.
115	5½ miles south of west of Bridgeport, sec. 3, T. 4 N., R. 24 E.	Buckeye Hot Spring	Terrace of granitic boulders and gravel. Near zone of faulting.	140	25	16, p. 291; 23, p. 132.	Bathing.
116	1½ miles southeast of Bridgeport, sec. 27, T. 5 N., R. 25 E.		Slopes of fissured andesitic lava.	121–148	10	16, p. 291; 23, pp. 133–135*.	3 springs; bathing and sheep dipping. Travertine ridges deposited; onyx marble and travertine quarried.
117	1½ miles east of south of Bridgeport		Andesitic lava	70–105	25	16, p. 291; 23, p. 133.	20 springs; not used.
118	Warm Springs Flat, 5 miles southeast of Bridgeport.		Tertiary lava	100	10	16, p. 291; 23, p. 135.	1 spring; cattle watering.
119	Near Mormon Creek, 7 miles southeast of Bridgeport, sec. 20, T. 4 N., R. 26 E.		do	100	10	23, p. 135	Do.
120	Paoha Island, in Mono Lake		Recent lava	176	100	16, p. 372; 23, p. 144; 167, p. 27*.	1 spring; not used.
121	East edge of Mono Lake	Mono Basin Warm Spring	Issues from tufa dome, in area of recent lava.	90	10	16, p. 288*; 23, pp. 145–146*; 167, p. 27*; 173, pp. 254–256*.	Not used.
122	5 miles northeast of Casa Diablo Hot Springs, sec. 13, T. 3 S., R. 28 E.		Faulting in recent lava	170	5	23, p. 147	1 spring; not used.

123	35 miles northwest of Bishop, sec. 32, T. 3 S., R. 28 E., on U. S. Highway 395.	Casa Diablo Hot Springs	Lava	115–194	35	16, p. 291; 23, p. 146, 174.	About 20 springs; vapor baths. Deposit small amounts of cinnabar.
124	3 miles northeast of Casa Diablo, sec. 35, T. 3 S., R. 28 E.	Casa Diablo Hot Pool	Base of small lava bluff; probable small fault scarp.	180	(4)	23, p. 147	Not used.
125	On Hot Creek, sec. 30, T. 3 S., R. 29 E.	"The Geysers"	Rhyolite lava	120–202[3]	500	174	5 principal springs; not used; 2 steam vents; large tufa deposit.
126	Long Valley, 38 miles northwest of Bishop.		Area of comparatively recent volcanic activity and faulting.	74–100	450	23, p. 147	4 springs; not used.
126a	37 miles northwest of Bishop, sec. 18, T. 4 S., R. 29 E.	Whitmore Warm Springs	Lava area	96	306	174	2 main springs; bathing resort.
127	300 yards northwest of Benton post office, sec. 2, T. 2 S., R. 31 E.	Benton Hot Spring	Issues from granitic rock near white volcanic tuff, which contains rounded lava gravel.	135	400	14, p. 196; 23, p. 136.	Irrigation.
	Madera County						
128	65 miles by road southeast of Yosemite, 10 miles southwest of Mineral Park.	Reds Meadows Hot Springs.	Issue from granitic material, near basaltic lava.	90–120	10	23, pp. 55–56 *	5 springs; camping ground.
	Fresno County						
129	Head of Fish Valley, 80 miles southeast of Yosemite, sec. 9, T. 5 S., R. 27 E.	Fish Creek Hot Springs	Granite	110	5	23, p. 56	2 springs; not used.
130	30 miles north of east of Shaver, sec. 16, T. 7 S., R. 27 E.		do	100–112	25	23, p. 55	4 springs; camping ground. Lower springs on South Fork of San Joaquin River.
131	30 miles north of east of Shaver, sec. 10, T. 8 S., R. 28 E.	Blaney Meadows Hot Springs.	Schistose gneiss	100–110	40	23, pp. 54–55 *	8 springs; camping ground.
132	25 miles south of Dos Palos	Mercey Hot Springs	In open draw at base of cherty gravel slopes, near dike of serpentine gabbro.	79–109	6	23, pp. 78–79*; 24, pp. 212–213*.	3 springs; bathing; formerly bottled. Saline.
133	Branch of Waltham Creek, 18 miles west of Coalinga.	Fresno Hot Springs	Faulting in shale and sandstone.	88–97	20	23, p. 78	5 springs; resort.
	Tulare County						
134	South Fork of Middle Fork of Tule River, 27½ miles north of east of Portersville.		Granite	77	25	23, p. 242	1 spring; drinking; carbonated.
135	65 miles north of Kernville	Jordan Hot Springs	Lime-cemented granitic gravel, near lava.	95–123	75	23, p. 53	14 springs; camping ground.
136	Monache Meadows, 14 miles southwest of Olancha.		Issues at base of rhyolite hill.	100	2	23, p. 246	1 spring; drinking; carbonated.
137	35 miles southeast of Portersville, sec. 31, T. 23 S., R. 31 E.	California Hot Springs	Fracturing and fault in granitic rock.	105–126	50	23, p. 49	7 springs; resort. Also called Deer Creek Hot Springs.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.
[3] Boiling.
[4] Intermittent.

Data on thermal springs in the United States—Continued

California—Continued

[See pl. 15]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Inyo County						
138	8 miles south of Bishop	Keough Hot Springs	Probable fault in granitic rocks.	130	825	23, p. 148; 174	3 springs; resort; bathing.
139	Saline Valley, 30 miles east of north of Keeler, 10 miles northeast of Saline Valley borax works.		Alluvium	100	5	23, p. 136	1 spring; prospector's supply.
140	Staininger ranch, Grapevine Canyon, 50 miles northeast of Keeler.	Grapevine Springs	Tertiary lake beds	75	30	23, p. 342; 92, p. 20	Several springs; domestic and irrigation.
141	14 miles southeast of Haiwee		Tertiary lava	150–203		14, p. 194; 23, p. 150	20 springs; not used. Sulphur and alum. Vapor but no flow of water in 1908.
141a	2 miles northwest of Coso Hot Springs	Devil's Kitchen [2]	Recent lava	Boiling	Small	174	Vapor vents; deposit small amounts of cinnabar.
142	20 miles northeast of Little Lake	Coso Hot Springs	Granitic rocks and Recent lavas.	([5])	do	23, p. 150*	3 main springs; resort; vapor baths.
143	Near Little Lake, 18 miles south of Haiwee.		Near basaltic bluff	80	1	14, p. 194; 23, pp. 148–149*.	1 spring; not used.
144	Panamint Valley, 4 miles north of Ballarat.		Alluvium; near granitic rocks.	80	1	23, p. 136	1 spring; roadside watering.
145	5 miles northeast of Zabriskie, sec. 1, T. 21 N., R. 7 E.	Yeoman Hot Springs	Alluvium; near Tertiary lava	80	100	27, p. 269; 33, p. 575	Several springs; irrigation.
146	3 miles southeast of Zabriskie		Fracture zone of fault in quartzite.	109	225	23, p. 137	2 springs; railroad water.
147	5½ miles northeast of Tecopa	Resting Spring	Probable fault in quartzite	80	260	23, p. 319	Domestic and irrigation.
	Kern County						
148	2 miles northeast of Kernville		Fault zone in granitic gneiss	98, 113	4	14, p. 199; 23, p. 50	2 springs; bathing.
149	7 miles west of south of Kernville	Neills Hot Spring	In Hot Spring Valley, which lies along fault zone.	131	115	14, p. 199; 23, p. 51	Domestic; bathing; irrigation. Also called Agua Caliente Spring.
150	51 miles northeast of Bakersfield, sec. 25, T. 27 S., R. 32 E.	Clear Creek Hot Springs	Granite	119	20	23, p. 51	3 springs; local use. Locally called Hobo Springs.
151	45 miles northeast of Bakersfield	Delonegha Springs	Fractured massive granite	104–112	25	23, p. 51	3 springs; resort.
152	40 miles northeast of Bakersfield	Democrat Springs	Fault in granitic rocks	100–115	25	23, p. 51	5 springs; resort.
153	16 miles northeast of Caliente	Williams Hot Springs	Fracture zone in quartz ledges and granitic gneiss.	60–100	20	23, p. 52	5 springs; domestic, irrigation, bathing.

	San Bernardino County						
154	15 miles west of Sperry railroad station	Saratoga Springs	Faulted area and intrusive diorite.	82	125	23, p. 137; 28, p. 24; 33, p. 131*.	4 springs; prospector's supply.
155	25 miles north of Daggett	Paradise Springs	Granitic rocks	85–102	25	23, p. 52; 33, p. 130*	Do.
156	Soda Station, sec. 14, T. 12 N., R. 8 E	Soda Station Springs	Alluvium and limestone; contact or fault.	75	30	33, p. 529*	2 springs; drinking.
157	600 yards south of Newberry railroad station, sec. 32, T. 9 N., R. 3 E.	Newberry Spring	Alluvium; near Tertiary lava	77	300	23, p. 314; 33, p. 501	Pumped for railroad supply.
158	Lytle Canyon, 15 miles northwest of San Bernardino.		Granitic rocks	92	5	14, p. 196; 23, p. 35	1 spring; not used.
159	Deep Creek Canyon, 16 miles southeast of Victorville, sec. 15, T. 3 N., R. 3 W.		Granite	80–100	5	174	Several springs; not used.
160	Deep Creek Canyon, 15 miles southeast of Victorville, sec. 14, T. 3 N., R. 3 W.		do	80–100	5	174	6 springs; not used.
161	6½ miles east of north of San Bernardino	Waterman Hot Spring	Fissures in granite and gneiss	123	5	14, p. 192; 23, pp. 33–35*.	Bathing.
162	7 miles east of north of San Bernardino	Arrowhead Hot Springs	Issue in fault zone from Tertiary sediments overlying granitic rocks.	110–187	50	23, pp. 32–33*; 173, pp. 233–236*.	2 springs; resort.
163	Santa Ana Canyon, 12 miles north of east of San Bernardino; sec. 34, T. 1 N., R. 2 W.		Granite	90	3	174	1 spring; not used.
164	Baldwin Lake, 40 miles southeast of Victorville.		Granitic rocks	88	5	23, p. 35	1 spring; bathing.
	Orange County						
165	7 miles southwest of Santa Ana	Fairview Hot Spring	Deep alluvium; artesian structure due to bedrock dam of shale.	96	15	23, p. 37	Resort; bottled.
166	13 miles northeast of Capistrano	San Juan Capistrano Hot Springs.	Granitic rock near base of steep slopes, possibly faulted.	121–124	35	14, p. 193; 23, pp. 48–49*.	6 springs; resort. Visited by Franciscan friars and mentioned in their records.
	Riverside County						
167	11 miles east of south of Corona	Glen Ivy Hot Spring	Fault zone in granite	102	15	23, p. 42; 25, p. 79	Resort. Formerly called Temescal Hot Spring.
168	⅛ mile north of Elsinore depot	Bundys Elsinore Hot Springs.	Issues from tule mud in fault zone.	118		23, p. 43*; 25, p. 75	Resort. Original flow, later pumped.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.
[2] Not shown on pl. 8.
[5] 140° to boiling.

Data on thermal springs in the United States—Continued

California—Continued

[See pl. 15]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Riverside County—Continued						
169	50 yards northwest of Elsinore depot	Elsinore Hot Springs	Issue from Tertiary sediments, in fault zone.	125		23, p. 42; 25, pp. 75, 78*; 173, pp. 247–248*.	3 springs; resort. Original flow, later pumped.
170	4 miles north of east of Murrieta	Murrieta Hot Springs	Fault zone; granitic rocks	134–136	75	23, p. 44*; 25, p. 86*	3 springs; resort.
171	8 miles northeast of Perris	Pilares Hot Spring	Bedrock dam causing artesian spring in alluvium; also possible fault.	100	3	23, p. 40; 25, p. 43	Bathing; drilled well also obtains warm water.
172	9 miles southwest of Beaumont	Eden Hot Springs	Issue at base of granitic slope, near border of Tertiary sediments, along course of San Jacinto fault.	90–110	30	23, p. 37; 25, pp. 24, 30*.	8 springs; resort.
173	6 miles northwest of San Jacinto	San Jacinto Hot Springs	Granitic alluvium	83–116	20	23, p. 38*; 25, pp. 24–30*.	6 springs; resort. Formerly Relief Hot Springs.
174	2½ miles northeast of San Jacinto	Ritchey Hot Springs	Crushed gneiss; landslides indicate crushing and slipping of rocks.	70–111	25	23, p. 39–40*; 25, pp. 25–30*.	6 springs; resort; bottled. Formerly Soboba Hot Springs.
175	6 miles south of Palm Springs station	Palm Springs	Fault in granitic rocks	100	5	23, p. 40*; 29, pp. 198, 283*.	2 springs; resort.
176	Northeast side of Salton Sink, 6 miles east of Salton railroad station.	Dos Palmas Spring	Alluvium and Tertiary sediments; artesian conditions.	80	25	16, p. 196*; 23, p. 315*; 29, pp. 247, 282*.	Prospectors' supply.
	San Diego County						
177	20 miles east of north of Oceanside	Deluz Warm Springs	Dike of diorite cuts granitic rock.	84–88	5	23, p. 47	3 springs; local use.
178	30 miles northeast of Oceanside	Agua Tibia Spring	Fault zone in granitic rocks	92	10	23, p. 47*	Bathing, irrigation.
179	65 miles northeast of San Diego, sec. 36, T. 10 S., R. 3 E.	Warner Hot Springs	Granitic rocks; fault	131–139	150	23, pp. 45–46*; 26, p. 205; 29, pp. 221, 283*; 173, pp. 267–269*.	6 springs; resort. Also called Agua Caliente Springs.
180	37 miles southeast of Julian, secs. 18 and 19, T. 14 S., R. 7 E.	Agua Caliente Springs	Fault zone in granite	90	20	23, p. 46; 29, p. 232	Several springs; not used.
181	80 miles south of east of San Diego, 24 miles east of Campo, secs. 7 and 8, T. 18 S., R. 8 E.	Jacumba Springs	Local faulting and fracturing in granite.	96	15	23, p. 45; 29, p. 211	2 springs; bathing, irrigation.

	Imperial County						
182	West side of Salton Sea, 13 miles south of Mecca.	Fish Springs	Alluvium; artesian conditions.	90	280	23, p. 315; 29, p. 203	Several springs; prospectors' supply.

Colorado

[See pl. 13]

	Moffat County						
1	Yampa River, 25 miles west of Craig, sec. 16, T. 6 N., R. 94 W.	Juniper Hot Springs	Cretaceous sedimentary rocks near Juniper Mountain uplift.	105	25	47, p. 216; 174	Several springs; resort.
	Routt County						
2	Mad Creek, 7 miles north of Steamboat Springs, Routt National Forest.	Routt Hot Springs	Fractured gneiss near contact with granite.	150	60	174	Picnic ground.
2a	Steamboat Springs	Steamboat Springs [2]	Issue from folded and faulted Dakota (?) sandstone; near contact with pre-Cambrian crystalline rock.	103–150	2,000	40, p. 35; 41, p. 438; 42, p. 359; 47, pp. 235–238, 438–450*; 49, p. 6; 173, pp. 296–299*.	Greatest group in Colorado. About 150 springs; resort; tufa deposits.
	Grand County						
3	Hot Sulphur Springs	Hot Sulphur Springs	Near contact of Cretaceous sedimentary rocks with pre-Cambrian granite and gneiss.	90–118	40	34, p. 184; 40, p. 35; 41, p. 438; 42, p. 357; 47, pp. 321*, 326*; 173, pp. 282–284*.	About 25 springs; resort; sanitarium; strong sulphur odor; tufa deposits.
	Boulder County						
4	12 miles southwest of Boulder	Moffat Spring	Juncture of impervious marly beds of Jurassic with underlying quartzite beds of Triassic; noted for faults.	84	12	42, p. 359; 40, p. 34; 47, p. 210.	Moffat Lakes resort.
	Clear Creek County						
5	Idaho Springs	Idaho Springs	Issue from fissures near contact of syenite with gneiss.	98–108	50	40, p. 35; 41, p. 438; 43, p. 37; 45, pp. 163–169*; 47, p. 214; 166, p. 485*; 173, pp. 284–286*.	Several springs; resort.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.
[2] Not shown on pl. 8.

Data on thermal springs in the United States—Continued

Colorado—Continued

[See pl. 13]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Garfield County						
6	Glenwood Springs	Glenwood Springs	Faulted and fissured zone in Cretaceous and Carboniferous sediments; issue from limestone, but granite at moderate depth.	106–125	3,000	40, p. 34; 41, p. 438; 45, p. 167; 47, pp. 210, 295*; 173, pp. 279–281*.	Many springs; resort. Issue from bed and bank of Colorado River; outlet formerly higher.
	Eagle County						
7	North bank of Colorado River, 1½ miles below Dotsero.	Big Dotsero Spring	Carboniferous blue sandy limestone.	84	400	47, pp. 209, 288*	Bathing.
	Pitkin County						
8	Near Avalanche, 12 miles south of Carbondale.	Avalanche Springs	Diorite; area of Permian and pre-Permian Carboniferous sedimentary rocks cut by diorite intrusion.	112–134	200	47, pp. 203, 254*	5 springs, for ¼ mile along Rock Creek (Crystal River); bathing.
9	16 miles by trail south of Aspen		Decomposed granite	90	500	174	1 spring; not used.
	Delta County						
10	Austin, between Cold Sulphur Spring and State bridge.	Alkali Springs	Dakota (?) sandstone	72	5	47, pp. 202, 252*	Several small springs; not used.
	Gunnison County						
11	10 miles east of Somerset, sec. 21, T. 13 S., R. 89 W.		Cretaceous sandstone	90	3	174	4 springs; not used.
12	Cement Creek 1½ miles above its mouth, 5 miles southeast of Crested Butte.	Cement Creek Spring	Limestone, near pre-Cambrian granite.	83	40	47, pp. 207, 273*	Not used; has formed mound of travertine.
13	Cement Creek 2½ miles above its mouth, 6 miles southeast of Crested Butte, sec. 18, T. 14 S., R. 84 W.		Cretaceous limestone	100	1,800	174	1 spring; not used.

14	28 miles east of Gunnison	Waunita Hot Springs	Sandstone, probably Paleozoic.	140–160	1,000	47, p. 239; 169, p. 190; 173, pp. 303–304*.	More than 100 springs in 2 groups ½ mile apart. Also called Tomichi Hot Springs.
15	Cebolla Creek, 6 miles south of Powderhorn.	Cebolla Hot Springs [2]	Pre-Cambrian granite, gneiss, and schist intruded by dikes.	84–115	100	37, p. 37; 47, p. 229	20 springs in 2 groups; resort. Also called Ojo de los Caballos.
	Park County						
16	8 miles southwest of Fairplay	Rhodes Spring	Alluvium	79	300	47, 210–294*	Local use.
17	25 miles east of Leadville	Hartsel Hot Springs	Near contact of granite and Mesozoic sedimentary rocks.	105–134	10	38, p. 38; 47, pp. 212, 311*; 166, p. 151; 173, pp. 281–282*.	5 springs; resort.
18	20 miles northwest of Parkdale, 9 miles below head of Currant Creek.	Mound Soda Spring	Granite	70		166, pp. 151, 484	Not used.
	Chaffee County						
19	Cottonwood Creek, 6 miles west of Buena Vista.	Cottonwood Springs	Near contact between pre-Cambrian granite and great monzonite intrusion.	120–144	150	47, pp. 205, 264*	5 springs; camping ground. Also called Buena Vista Hot Springs.
20	3 miles west of Nathrop	Mount Princeton Springs	Contact of white felspathic granite with great monzonite mass.	98–150	50	40, p. 35; 47, p. 223; 166, p. 484.	About 35 springs: resort. Formerly Heywood Hot Springs and Chalk Creek Hot Springs.
21	Poncha Springs	Poncha Springs	Granite	80–168	500	40, p. 35; 41, p. 438; 47, p. 229; 173, pp. 292–294*.	About 100 springs; resort; tufa deposits.
	Fremont County						
22	5 miles northwest of Howard	Wellsville Warm Spring	Carboniferous rocks	94	150	47, pp. 243, 468*; 166, p. 151.	Local use.
	Saguache County						
23	6 miles south of Villa Grove, sec. 12, T. 45 N., R. 9 E.	Chamberlain Hot Springs	Ancient sedimentary rocks overlain by lava.	116–133	50	46, p. 103; 47, p. 222.	30 springs; resort; tufa deposits.
24	7 miles southeast of Villa Grove, sec. 31, T. 46 N., R. 10 E.	Valley View Hot Springs	Quartzite in granitic area	87–99	300	46, pp. 104, 112*; 47, p. 226.	5 springs; local use.
	Pueblo County						
25	Red Creek, 12 miles southwest of Pueblo.	Red Creek Springs	Contact of sedimentary rocks and pre-Cambrian gneiss.	59–73	5	47, pp. 233, 426*; 166, pp. 619–620*.	5 springs; local use; tufa deposits. Also called Parnassus Springs.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.
[2] Not shown on pl. 8.

Data on thermal springs in the United States—Continued

Colorado—Continued

[See pl. 13]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	San Miguel County						
26	Placerville	Geyser Warm Spring	Mesozoic sedimentary rocks	94	5	47, pp. 227, 393*	Bathing.
	Ouray County						
27	2 miles southeast of Ridgway	Orvis Hot Spring	Alluvium, underlain by faulted rocks of Pennsylvanian age.	132	300	37, p. 41; 44, p. 20; 47, p. 232.	Bathhouse and pool. Irrigation. Formerly called Ridgway Hot Spring.
28	Ouray	Ouray Hot Springs	Issue from faulted limestone of Hermosa formation (Pennsylvanian).	100–158	200	44, p. 19*; 46, p. 324; 47, p. 226; 48, p. 67; 173, pp. 294–296*.	3 groups; resort; 2 sanitariums and municipal pool.
	Dolores County						
29	200 yards southeast of Dunton Store, 7 miles north of Rico, sec. 33, T. 41 N., R. 11 W.		Cretaceous limestone	110	20	174	1 spring; local use.
30	¾ mile north of Rico	Iron Spring	Permian sandstone and shale	82	30	47, pp. 232, 418*	Limonite deposit; not used.
	Mineral County						
31	Wagon Wheel Gap	Wagon Wheel Gap Springs	Granite cut by dikes	105–150	100	37, pp. 154, 155*; 40, p. 35; 47, p. 239; 166, pp. 621*, 623; 173, pp. 301, 302*.	3 springs; resort.
32	26 miles northeast of Pagosa Springs, sec. 26, T. 38 N., R. 1 W.		Granite	100, 120	50	174	2 springs; not used.
	Rio Grande County						
33	6 miles north of Del Norte	Shaw's Spring	Tertiary sandstone, near igneous rocks.	88	10	47, pp. 208, 282*	Local use.

	La Plata County						
34	14 miles north of Durango, sec. 26, T. 37 N., R. 9 W.	Pinkerton Springs	Paleozoic formations, near pre-Cambrian rocks.	87–95	8	47, pp. 210, 291*	5 large springs and several small ones; resort.
35	10 miles north of Durango	Tripp Springs	Cretaceous sandstone	90–95	50	47, pp. 238, 434*	Several springs. Bathhouse and pool.
36	9 miles north of Durango, sec. 15, T. 36 N., R. 9 W.	Trimble Springs	Paleozoic and Mesozoic rocks, folded and fissured.	90–110	50	40, p. 35; 47, p. 238	5 springs; resort. Large mound of tufa.
	Archuleta County						
37	30 miles by trail west of Pagosa Springs, sec. 8, T. 35 N., R. 4 W.		Limestone, probably of Carboniferous age.	120	3	174	5 small springs; camping ground.
38	12 miles northeast of Pagosa Springs		Shale of Colorado group overlain by lava.	78		166, p. 151	1 spring; not used.
39	Pagosa Springs	Pagosa Hot Springs	Fissure zone in closely folded Cretaceous shale of Colorado group.	110–160	600	37, pp. 183–185; 39, p. 83; 40, p. 35; 41, p. 438; 47, p. 226; 166, pp. 478–483, 627*; 173, pp. 291–292*.	Several springs; resort. Large deposit of sinter.
40	3 miles southeast of Pagosa Springs		Shale of Colorado group (Upper Cretaceous).	120		166, p. 151	1 spring; not used.
41	South Fork of Navajo River, 7 miles east of Chromo.	Warm Sulphur Spring	Cretaceous sediments overlain by lava.	80		166, pp. 620–621*; 169, pp. 188, 191*.	Not used.
	Conejos County						
42	Upper course of La Jara Creek, 2 miles southwest of Capulin, T. 35 N., R. 8 E.	Agua Caliente Spring	Alluvium near Quaternary lava.	90	50	46, p. 104; 166, p. 626.	Irrigation.
43	8 miles east of La Jara, sec. 13, T. 35 N., R. 10 E.	McIntyre Warm Springs	Issue from crevices in Quaternary lava.	62	600	39, p. 78; 46, p. 101; 47, p. 217.	Several springs; irrigation. Formerly Los Ojos Springs.
44	12 miles east of La Jara, sec. 9, T. 35 N., R. 11 E.	Dexter Spring	Edge of lava bench	71	5	46, p. 112*; 47, p. 243.	Not used.

Georgia

[See pl. 10]

	Pike County						
1	6 miles south of Zebulon	Lifsey Spring	Probable faulting in quartzite of Pine Mountain.	77	100	55, pp. 102–103*; 56, p. 373*; 173, pp. 331–332*.	Resort. Formerly Pine Mountain Spring.
1a	9½ miles east of Molena	Taylor Spring	Quartzite of Pine Mountain	75	385	174	Supplies pool.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

Data on thermal springs in the United States—Continued

Georgia—Continued

[See pl. 10]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Upson County						
2	Near Thunder Station	Thundering Springs	Probable faulting in quartzite of Pine Mountain.	74	30	55, pp. 157–158*; 56, p. 373*; 173, pp. 336–337*.	2 springs; local use.
3	500 yards south of Thundering Springs		Quartzite of Pine Mountain	69–72½	25	174	4 springs; unused.
4	6 miles southeast of Thundering Springs	Barker Spring	do	73	10	174	Swimming pool.
	Meriwether County						
5	Warm Springs	Warm Springs	Water issues at contact of schist overlying northward-dipping quartzite at north base of Pine Mountain.	87	600	52, p. 230; 53, pp. 14, 241; 55, pp. 166, 167*; 56, p. 373*; 173, pp. 338–339*.	1 main spring; resort; sanitarium.
6	3 miles southeast of Warm Springs	Parkman Pond	Quartzite of Pine Mountain	77	20	174	Supplies mill pond.
7	2½ miles northeast of Chalybeate	Tom Brown Spring	do	69	25	174	Supplies pond.

Idaho

[See pl. 11]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Idaho County						
1	7 miles west of Jerry Johnson's Hot Springs, NW¼ sec. 13, T. 36 N., R. 11 E., Selway National Forest.	Weir Creek Hot Springs	Granite	Hot	5	174	6 springs; not used.
2	4 miles west of Jerry Johnson's Hot Springs, NE¼ sec. 9, T. 36 N., R. 12 E., Selway National Forest.	Colgate Springs	Granite wash	105–120	20	174	Do.
3	Warm Springs Creek, SE¼ sec. 7, T. 36 N., R. 13 E., Selway National Forest.	Jerry Johnson's Hot Springs.	Granite	100–130	450	62, p. 113; 174	3 springs; bathing.
4	Horse Creek, 4 miles northeast of Jerry Johnson's Hot Springs.		do	80	200	174	1 spring; not used.

5	Near Boulder Creek, 4 miles above its junction with Lochsa River, NW¼ sec. 6, T. 34 N., R. 10 E., Selway National Forest.	Stanley Hot Spring	do	Hot	2	174	Not used.
6	Link Creek 5 miles above its junction with Selway River, NW¼ sec. 4, T. 32 N., R. 11 E., Selway National Forest.	Stuart Hot Spring	do	do	35	174	Do.
7	11 miles southwest of Elk Summit ranger station, NE¼ sec. 4, T. 33 N., R. 14 E., Selway National Forest.		do	Warm	40	174	2 springs; not used.
8	3¼ miles west of Wylies Peak, NE¼ sec. 25, T. 31 N., R. 11 E., Selway National Forest.	Martin Creek Hot Springs	do	Hot	15	174	6 springs and seeps; not used.
9	2 miles south of Grouse Peak, SE¼ sec. 14, T. 29 N., R. 12 E., Selway National Forest.		do	do	10	174	1 spring; not used.
10	10 miles northeast of Red River ranger station, sec. 10, T. 28 N., R. 10 E., Nezperce National Forest.	Red River Hot Springs	do	120	15	174	4 springs; resort.
11	Salmon River 200 yards below mouth of Hot Springs Creek, NW¼ sec. 13, T. 25 N., R. 11 E., Idaho National Forest.	Barht's Hot Springs	do	Hot	200	174	Several springs; local use.
12	2 miles north of Salmon River, sec. 7, T. 24 N., R. 4 E., Nezperce National Forest.		do	110	10	174	1 spring; bathing.
13	South side of Salmon River, 10 miles east of Riggins, sec. 13, T. 24 N., R. 2 E.	Riggins Hot Spring	do	Hot		174	Local use.
14	Resort, SE¼ sec. 1, T. 22 N., R. 4 E., Idaho National Forest.	Burgdorf Hot Spring	do	113	150	174	1 spring; resort.
15	East side of Little Salmon River, 3 miles north of Round Valley, sec. 13, T. 21 N., R. 1 E.		do	Hot		174	1 spring; not used; sulphur odor.
	Adams County						
16	West side of Little Salmon River, 10 miles northwest of Meadows, sec. 26, T. 20 N., R. 1 E.	Yoghann Hot Sulphur Spring.	Columbia River basalt	do		174	Not used.
17	3 miles northeast of Meadows, SW¼ sec. 22, T. 19 N., R. 2 E., Idaho National Forest.		Granite	100	50	174	1 spring; bathing.
18	1¼ miles north of mouth of Warm Spring Creek, SW¼ sec. 2, T. 15 N., R. 1 E., Weiser National Forest.		do	Hot	100	174	6 springs; not used.
19	15 miles east of Cottonwood, NW¼ sec. 33, T. 16 N., R. 2 E., Weiser National Forest.		do	do	25	174	8 springs; not used.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

Data on thermal springs in the United States—Continued

Idaho—Continued

[See pl. 11]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Washington County						
20	Snake River Canyon above Brownlee Creek, T. 17 N., R. 5 W.		Columbia River basalt	Hot		114, p. 641	1 spring; not used; sulphur odor.
21	Monroe Creek, 6 miles northeast of Weiser, T. 11 N., R. 5 W.		Tertiary lake beds of Payette formation.	Warm		63, p. 34	Several springs; not used.
	Valley County						
22	12 miles west of Shiefers, SE¼ sec. 11, T. 21 N., R. 5 E., Idaho National Forest.		Granite	Hot	100	174	10 springs; not used.
23	15 miles southwest of Shiefers, SE¼ sec. 15, T. 20 N., R. 5 E., Idaho National Forest.		do	Warm	5	174	1 spring; not used.
24	South Fork of Salmon River, 7 miles south of Shiefers, NE¼ sec. 35, T. 20 N., R. 7 E., Idaho National Forest.		do	90–136	100	174	About 25 springs, covering 40 acres; not used.
25	South Fork of Salmon River, 25 miles north of Knox, SW¼ sec. 35, T. 18 N., R. 6 E., Idaho National Forest.		do	Hot	15	174	10 springs; not used.
26	Near mouth of Riordan Creek, Yellow Pine Basin, NE¼ sec. 17, T. 18 N., R. 8 E., Payette National Forest.		do	90	2	174	1 spring; not used.
27	10 miles north of Cascade, about T. 15 N., R. 3 E.		do	Hot		174	Several springs; not used.
28	Gold Fork River, 25 miles north of Cascade, about T. 16 N., R. 4 E.		do	do		174	Do.
29	South Fork of Salmon River, 15 miles north of Knox, NW¼ sec. 1, T. 16 N., R. 6 E., Idaho National Forest.		do	do	2	174	2 springs; not used.
30	6 miles north of Knox, SW¼ sec. 17, T. 15 N., R. 6 E., Payette National Forest.		do	do	100	174	1 spring; not used.
31	6 miles northeast of Knox, sec. 14, T. 15 N., R. 6 E., Payette National Forest.		do	do	250	174	1 spring in NW¼ sec. 14, 200 gallons a minute; 1 spring in SW¼ sec. 14, 50 gallons a minute; not used.

32	4 miles east of Knox, NE¼ sec. 11, T. 14 N., R. 6 E., Payette National Forest.		do	Hot	450	174	6 springs; not used.
33	4 miles southeast of Knox, NE¼ sec. 14, T. 14 N., R. 6 E., Payette National Forest.		do	do	100	174	1 spring; not used.
34	¼ mile from Cascade, T. 14 N., R. 3 E.		do	do	20	174	2 springs, ¼ mile north and ¼ mile south of Cascade; town water supply.
35	Middle Fork of Payette River, 12 miles east of Alpha, SE¼ sec. 2, T. 12 N., R. 5 E., Payette National Forest.		do	do	35	174	1 spring; not used.
36	Near Middle Fork of Payette River, NW¼ sec. 11, T. 12 N., R. 5 E., Payette National Forest.		do	100	15	174	Several springs; not used.
37	Near Middle Fork of Payette River, NW¼ sec. 15, T. 12 N., R. 5 E., Payette National Forest.		do	90	15	174	1 spring; not used.
38	Near Middle Fork of Payette River, NW¼ sec. 22, T. 12 N., R. 5 E., Payette National Forest.		do	Hot	150	174	5 springs; not used.
39	Near Bull Creek, 15 miles east of Alpha, NW¼ sec. 28, T. 13 N., R. 6 E., Payette National Forest.		do	do	15	174	3 springs; not used.
40	Near Silver Creek, 15 miles southeast of Alpha, NW¼ sec. 31, T. 12 N., R. 6 E., Payette National Forest.		do	90	250	174	4 springs; not used.
41	½ mile southwest of mouth of Bear Valley Creek, SW¼ sec. 23, T. 13 N., R. 10 E., Payette National Forest.		do	Hot	10	174	1 spring; not used.
42	¼ mile from mouth of Dagger Creek, SW¼ sec. 30, T. 14 N., R. 10 E., Payette National Forest.		do	Warm	2	174	Do.
43	Sulphur Creek, NE¼ sec. 13, T. 14 N., R. 9 E., Payette National Forest.		do	80–110	7	174	3 springs; not used.
44	Near Middle Fork of Salmon River, near mouth of Sulphur Creek, NE¼ sec. 34, T. 15 N., R. 10 E., Payette National Forest.		do	Hot	25	174	Do.
45	Near Middle Fork of Salmon River, NW¼ sec. 26, T. 15 N., R. 10 E., Payette National Forest.		do	do	3	174	2 springs; not used.
46	Branch of Indian Creek near Chinook Mountain, NW¼ sec. 17, T. 16 N., R. 10 E., Payette National Forest.		Granite, overlain by Tertiary lava.	do	10	174	4 springs; not used.
47	About 10 miles north of Greyhound, NE¼ sec. 20, T. 16 N., R. 12 E., Challis National Forest.		Granite	do	40	174	2 springs; not used.
48	8 miles south of Roosevelt, NE¼ sec. 15, T. 17 N., R. 11 E., Payette National Forest.		Granite overlain by Tertiary lava.	do	50	174	10 springs; not used.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

Data on thermal springs in the United States—Continued

Idaho—Continued

[See pl. 11]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Valley County—Continued						
49	Middle Fork of Salmon River, 2 miles above White Creek, NE¼ sec. 28, T. 17 N., R. 13 E., Payette National Forest.		Lava overlying granite	Hot	10	174	3 springs; not used.
	Lemhi County						
50	Horse Creek, 25 miles northwest of Shoup, SE¼ sec. 17, T. 25 N., R. 17 E., Selway National Forest.		Granite	110	10	62, p. 114; 174	1 spring; not used.
51	17 miles west of Shoup, NW¼ sec. 32, T. 24 N., R. 17 E., Salmon National Forest.		do	Warm	25	174	5 springs; not used.
52	West side of Copper King Mountain on a tributary of Big Creek, T. 22 N., R. 18 E.		do	Hot		174	1 spring; not used.
53	5 miles north of Carmen, NE¼ sec. 22, T. 23 N., R. 22 E., Salmon National Forest.		do	do	80	174	14 springs; not used.
54	1 mile east of Mormon ranch, sec. 26, T. 19 N., R. 14 E., Salmon National Forest.		do	do	40	174	1 spring; not used.
55	Near Cache Creek, 4 miles above its mouth, NW¼ sec. 19, T. 17 N., R. 14 E., Challis National Forest.		do	Warm	10	174	Do.
56	Warm Spring Creek, NE¼ sec. 10, T. 15 N., R. 14 E., Challis National Forest.		Tertiary lava	80–190	400	174	9 springs; not used.
57	5 miles northwest of Parker Mountain, NE¼ sec. 1, T. 15 N., R. 15 E., Challis National Forest.		do	Warm	75	174	4 springs; not used.
58	Near Parker Mountain, sec. 16, T. 15 N., R. 16 E., Challis National Forest.		do	Hot	200	174	7 springs; not used.
59	7 miles south of Salmon, sec. 3, T. 20 N., R. 22 E.	Salmon Hot Springs	Bleached and altered lava	Warm	400	174	Several springs; irrigation, bathing.
60	7 miles northeast of Tendoy, SE¼ sec. 34, T. 20 N., R. 24 E.		Limestone of Belt series (pre-Cambrian).	Hot	200	174	1 spring; not used.

61	2 miles east of State highway, 27 miles south or Salmon, T. 18 N., R. 22 E., Salmon National Forest.		Quartzite of Belt series	Hot	200	174	2 springs; not used.
62	Kronk Canyon of Salmon River, 40 miles south of Salmon, T. 17 N., R. 21 E.		do	do	100	174	1 spring; not used.
63	Salmon River, at upper end of Kronk Canyon, 3 miles below mouth of Pahsimeroi River, NE¼ sec. 18, T. 16 N., R. 21 E., Lemhi National Forest.		do	do	100	174	6 springs; not used.
64	Warm Spring Creek, 4 miles southwest of Lemhi Indian Agency.		Ancient sedimentary rocks overlain by Tertiary lava.	Warm		169, p. 182	Several springs; local use.
65	10 miles west of Leadore, NW¼ sec. 4, T. 15 N., R. 25 E.		Porphyry of Belt series	87	3	174	1 spring; bathing.
	Gem County						
66	1 mile southwest of Sweet, sec. 9, T. 7 N., R. 1 E.		Lava overlying granite	Hot		174	Not used.
	Canyon County						
67	East side of Snake River, 1 mile east of Enterprise, T. 1 N., R. 3 W.		Gravel bed in lake beds; probable artesian structure.	67		60, p. 27; 61, p. 5	1 spring; not used.
	Ada County						
68	West bank of Squaw Creek, 3 miles north of Boise, T. 4 N., R. 2 E.		Sediments of Payette formation (Tertiary).	Hot	Large	58, p. 7	1 spring; local use.
69	Cottonwood Creek. 1 mile west of Boise City, T. 3 N., R. 2 E.		do	Warm		58, p. 7	Do.
70	4½ miles southeast of Boise, T. 3 N., R. 2 E.	Boise Hot Springs	Faulted sandstone of Payette formation.	90–140	255	58, p. 7; 59, p. 168; 60, p. 27.	About 16 springs; resort.
71	Near Grand View, NE¼ sec. 29, T. 5 S., R. 4 E.		Issues along fault in Quaternary lava.	109	100	174	1 spring; irrigation.
	Boise County						
72	14 miles north of McNish ranger station, SE¼ sec. 20, T. 10 N., R. 3 E., Payette National Forest.		Granite	Warm	30	174	1 spring; not used.
73	3 miles northwest of Garden Valley, sec. 32, T. 10 N., R. 4 E., Payette National Forest.		do	Hot		174	Do.
74	South Fork of Payette River, 10 miles east of Garden Valley SE¼ sec. 6, T. 8 N., R. 5 E., Payette National Forest.		do	do	20	174	2 springs; camping ground.
75	½ mile west of Danskin Creek, SE¼ sec. 2, T. 8 N., R. 5 E., Payette National Forest.		do	do	8	174	1 spring; not used.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

Data on thermal springs in the United States—Continued

Idaho—Continued

[See pl. 11]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Boise County—Continued						
76	1½ miles east of Boston & Idaho power plant, sec. 11, T. 8 N., R. 5 E., Payette National Forest.		Granite	Hot	15	174	2 springs; local use.
77	¼ mile west of Pine Flat, SW¼ sec. 31, T. 9 N., R. 6 E.		do	do	30	174	1 spring; camping ground.
78	North side of South Fork of Payette River, sec. 31, T. 9 N., R. 8 E., Boise National Forest.		do	Warm	40	174	1 spring; not used.
79	South Fork of Payette River, sec. 32, T. 9 N., R. 8 E., Boise National Forest.	Kirkham Hot Springs	do	90	150	174	5 springs covering 1 acre; not used.
80	Warm Spring Creek, near South Fork of Payette River, sec. 31, T. 10 N., R. 10 E., Boise National Forest.	Bonneville Hot Springs	do	100	200	174	6 springs covering ½ acre; not used.
81	South Fork of Payette River, near mouth of Bear Creek, sec. 30, T. 10 N., R. 11 E., Boise National Forest.	Sacajawea Hot Springs	do	100	100	174	3 springs; not used.
82	6 miles southwest of Idaho City, T. 5 N., R. 5 E.		do	110–115	900	169, p. 181; 171, p. 222.	6 springs; local use.
83	North side of Arrowrock Reservoir, near mouth of Cottonwood Creek, about sec. 1, T. 3 N., R. 5 E., Boise National Forest.	Nevin Spring	do	Hot	200	174	Not used.
84	North side of Middle Fork of Boise River below Browns Creek, Boise National Forest.	Twin Springs	do	do	350	174	2 main springs and several small ones, covering ½ acre; not used.
85	Above Logging Gulch, on north side of Middle Fork of Boise River, Boise National Forest.	Basset Hot Spring	do	do	30	174	Not used.
	Custer County						
86	2 miles northwest of Greyhound, SE¼ sec. 1, T. 14 N., R. 11 E., Challis National Forest.		do	Warm	4	174	1 spring; not used.

87	6 miles east of Cape Horn, NW¼ sec. 2, T. 12 N., R. 11 E., Challis National Forest.		do	Warm	200	174	Do.
88	10 miles southwest of Casto, NE¼ sec. 33, T. 14 N., R. 13 E., Challis National Forest.		do	do	3	174	Do.
89	Near Stanley, SW¼ sec. 15, T. 10 N., R. 12 E., Challis National Forest.		do	Hot	200	174	2 springs; not used.
90	Near mouth of Yankee Fork of Salmon River, sec. 36, T. 11 N., R. 13 E., Challis National Forest.		do	do	250	174	5 springs; not used.
91	4 miles east of mouth of Yankee Fork of Salmon River, sec. 20, T. 11 N., R. 14 E., Challis National Forest.		do	do	200	174	10 springs; not used.
92	6 miles east of mouth of Yankee Fork of Salmon River, secs. 22 and 27, T. 11 N., R. 14 E., Challis National Forest.		do	Warm	5	174	1 spring; not used.
93	Salmon River, 1 mile above Sunbeam Dam, SW¼ sec. 19, T. 11 N., R. 15 E.		do	168	200	174	6 springs; local use.
94	2 miles south of mouth of Yankee Fork of Salmon River, sec. 3, T. 10 N., R. 13 E., Challis National Forest.		do	Warm	400	174	5 springs; not used.
95	Mouth of Warm Spring Creek, NE¼ sec. 34, T. 11 N., R. 15 E., Challis National Forest.	Robinson Bar Ranch Hot Springs.	do	130	40	174	3 springs; resort.
96	Hot Creek near its mouth, T. 10 N., R. 15 E., Challis National Forest.		Carboniferous limestone	134-147		174	Several springs for ½ mile on Hot Creek, and others nearby on Warm Spring Creek; not used.
97	Loon Creek ½ to 1½ miles above mouth of Warm Spring Creek, T. 11 N., R 15 E., Challis National Forest.	Loon Creek Hot Springs	Faulted greenstone	115-136	700	174	About 20 springs; strong sulphur odor; local use.
98	Near head of Loon Creek, T. 10 N., R. 15 E., Challis National Forest.		Granite	Hot		174	Several springs; not used.
99	Slate Creek 6 miles above its mouth, SE¼ sec. 19, T. 10 N., R. 16 E., Challis National Forest.		Carboniferous slate overlain by Tertiary lava.	do	200	174	10 springs covering 2 acres; not used.
100	Sullivan Creek near Salmon River, 3 miles west of Clayton, sec. 27, T. 11 N., R. 17 E.	Sullivan Hot Springs	Paleozoic limestone near contact with Tertiary lava.	107	5,000	174	Local use; sulphur odor.
101	Salmon River, SW¼ sec. 18, T. 9 N., R. 14 E., Sawtooth National Forest.		Granite	105	150	174	1 spring; not used.
102	Pierson post office, NE¼ sec. 27, T. 8 N., R. 14 E.	Pierson Hot Spring	do	120	300	64, p. 223; 174	1 spring; resort.
103	East Fork of Salmon River, secs. 30 and 31, T. 8 N., R. 17 E., Sawtooth National Forest.		Carboniferous limestone near lava.	70-120	450	174	8 springs; not used.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

Data on thermal springs in the United States—Continued

Idaho—Continued

[See pl. 11]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Custer County—Continued						
104	East Fork of Salmon River, NW¼ sec. 6, T. 7 N., R. 17 E., Sawtooth National Forest.		do	75-110	300	174	6 springs; not used.
105	East bank of Salmon River, 4 miles east of Challis, sec. 23, T. 14 N., R. 19 E., Lemhi National Forest.	Beardsley Hot Springs	Faulted Paleozoic limestone and quartzite.	123	1,500	174	Several springs; resort.
106	15 miles northwest of Goldberg, NE¼ sec. 26, T. 14 N., R. 21 E.	Sulphur Creek Spring	Paleozoic rocks	57	1,500	67, p. 31	Irrigation.
107	Warm Springs Creek, 10 miles southeast of Challis, T. 13 N., R. 20 E.		Tertiary basalt	Warm	100	174	Several springs; not used.
108	Little Lost River Valley, about 6 miles south of its head, T. 9 N., R. 27 E.		Paleozoic rocks	80		67, p. 32	1 spring; not used.
	Elmore County						
109	South side of Middle Fork of Boise River, ¼ mile below Sheep Creek, Boise National Forest.		Granite	Hot	200	174	Do.
110	Middle Fork of Boise River at Sheep Creek Bridge, Boise National Forest.	Sheep Creek Bridge Spring.	do	do	100	174	Not used.
111	Sheep Creek near Middle Fork of Boise River, Boise National Forest.	Reed Spring	do	do		174	Do.
112	Both sides of Middle Fork of Boise River, above North Fork, Boise National Forest.	Smith Cabin Springs	do	do	900	174	Several springs covering 2 acres; not used.
113	North side of Middle Fork of Boise River below Loftus Creek, Boise National Forest.	Loftus Spring	do	do	100	174	Not used.
114	North side of Middle Fork of Boise River below Vaughn Creek, Boise National Forest.	Crevice Spring	do	do	20	174	Do.
115	South side of Middle Fork of Boise River above Vaughn Creek, Boise National Forest.	Vaughn Spring	do	do	200	174	Do.
116	South side of Middle Fork of Boise River below Big Five Creek, Boise National Forest.	Ninemeyer Springs	do	do	900	174	10 springs; not used.

117	North side of Middle Fork of Boise River above Pool Creek, Boise National Forest.	Pool Creek Spring	do	Warm	50	174	Not used.
118	South side of Middle Fork of Boise River above Straight Creek, Boise National Forest.		do	Hot	180	174	1 spring; not used.
119	South side of Middle Fork of Boise River below Dutch Frank's Creek, Boise National Forest.	Dutch Frank's Springs	do	do	1,800	174	Many springs covering 3 acres; not used.
120	Middle Fork of Boise River, 8 miles east of Narton, NW¼ sec. 4, T. 5 N., R. 9 E., Boise National Forest.	Granite Creek Springs	do	130	50	174	7 springs; not used.
121	Both sides of Middle Fork of Boise River ¼ mile above Granite Creek, T. 5 N., R. 9 E., Boise National Forest.		do	Hot	200	174	About 40 springs covering 2 acres; not used.
122	South side of Middle Fork of Boise River ½ mile below Granite Creek, NW¼ sec. 36, T. 6 N., R. 9 E., Boise National Forest.		do	130	30	174	Several springs covering 1 acre; bathing.
123	2 miles east of Atlanta, NW¼ sec. 32, T. 6 N., R. 12 E., Boise National Forest.		do	100-130	50	174	6 springs; bathing.
124	½ mile northeast of Featherville, NW¼ sec. 10, T. 3 N., R. 10 E., Sawtooth National Forest.		do	Warm	45	174	1 spring; bathing.
125	7 miles east of Featherville, NW¼ sec. 9, T. 3 N., R. 11 E., Sawtooth National Forest.		do	do	Small	174	1 spring; not used.
126	Willow Creek 10 miles northeast of Featherville, NW¼ sec. 24, T. 4 N., R. 11 E., Sawtooth National Forest.		do	Hot	45	174	Several springs; not used.
127	South Fork of Boise River, 10 miles east of Featherville, NE¼ sec. 13, T. 3 N., R. 11 E.		do	do	30	174	4 springs; not used.
128	6 miles south of Featherville, NE¼ sec. 5, T. 2 N., R. 10 E., Sawtooth National Forest.		do	do	50	174	12 springs covering 5 acres; bathing.
129	4½ miles south of Featherville, SE¼ sec. 33, T. 3 N., R. 10 E., Sawtooth National Forest.		do	128	45	174	12 springs covering 1 acre; bathing; camp ground.
130	North of Fishing Falls, about 60 miles southeast of Boise, sec. 5, T. 1 N., R. 10 E.		do	164		166, p. 150; 169, pp. 181, 182*.	Several springs; local use.
131	10 miles east of Mountain Home, sec. 16, T. 3 S., R. 8 E.	Hot Springs, Ranch Springs.	Faulted lava	103-167	900	59, p. 169; 60, p. 27	Several springs; bathing.
131a	15 miles north of Glenns Ferry	Daugherty's Hot Spring [2]	do	146	500	174	Irrigation; bathing; formerly Lattie's Hot Spring.
131b	1 mile east of King Hill	Hot Spring [2]	do	125	20	174	Irrigation; bathing. Original spring increased by drilled well.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.
[2] Not shown on pl. 8.

Data on thermal springs in the United States—Continued

Idaho—Continued

[See pl. 11]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Camas County						
132	Big Smoky Creek, 8 miles north of Carrietown; SW¼ sec. 1, T. 4 N., R. 14 E., Sawtooth National Forest.		Granite	Warm	10	174	1 spring; not used.
133	Big Smoky Creek, 8 miles northwest of Carrietown, NW¼ sec. 32, T. 4 N., R. 14 E., Sawtooth National Forest.		do	Hot	20	174	About 30 springs; not used.
134	South Fork of Boise River near mouth of Bear Creek, SW¼ sec. 18, T. 3 N., R. 13 E., Sawtooth National Forest.		do	Warm	15	174	15 springs; not used.
135	Little Smoky Creek, 8 miles southwest of Carrietown, NE¼ sec. 30, T. 3 N., R. 14 E.		do	do	10	169, p. 182; 174	1 spring; not used.
136	Little Smoky Creek, 6 miles southwest of Carrietown, SW¼ sec. 28, T. 3 N., R. 14 E., Sawtooth National Forest.	Wasewick Hot Springs	do	125–150	250	64, p. 223; 174	About 50 springs; local use.
137	Corral Creek, 2 miles north of Corral, SE¼ sec. 29, T. 1 N., R. 13 E., Sawtooth National Forest.	Wardrop Hot Springs	Tertiary lava	Hot	100	174	About 25 springs: resort.
138	5 miles north of Blaine, SE¼ sec. 14, T. 1 N., R. 15 E., Sawtooth National Forest.		do	Warm	15	174	1 spring; not used
139	5 miles south of Corral, SE¼ sec. 34, T. 1 S., R. 13 E., Sawtooth National Forest.		do	Hot	25	174	20 springs; not used.
	Blaine County						
140	Near Wood River, 18 miles northwest of Ketchum, SW¼ sec. 33, T. 6 N., R. 16 E., Sawtooth National Forest.	Russian John Hot Springs	Tertiary lava overlying Paleozoic rocks.	102	50	174	4 springs; not used.
141	South side of Wood River, 16 miles northwest of Ketchum, SE¼ sec. 11, T. 5 N., R. 16 E., Sawtooth National Forest.	Easly Warm Springs	do	99	100	174	Do.
142	2½ miles west of Ketchum, NW¼ sec. 15, T. 4 N., R. 17 E., Sawtooth National Forest.	Guyer Hot Springs	Water issues from joint planes in black limestone, near faulted zone.	160	450	69, p. 115; 174	Several springs; resort. Tufa deposit.

143	Warm Spring Creek, 11 miles southwest of Ketchum, SE¼ sec. 36, T. 4 N., R. 16 E., Sawtooth National Forest.		Tertiary lava overlying Paleozoic rocks.	Hot	450	169, p. 182; 174	6 springs; bathing.
144	Deer Creek 6 miles west of Hailey, NW¼ sec. 26, T. 3 N., R. 17 E., Sawtooth National Forest.	Clarendon Hot Springs	Paleozoic black limestone	125–150	100	64, p. 223; 69, p. 115; 174.	3 springs; bathing pool.
145	2½ miles southwest of Hailey, sec. 18, T. 2 N., R. 18 E.	Hailey Hot Springs	Paleozoic slate	146	50	69, p. 115; 174	Several springs; piped to baths and hotel in town.
146	Near Magic Reservoir, sec. 24, T. 1 S., R. 17 E.	Lava Creek Hot Spring	Snake River basalt overlying rhyolite.	96	130	174	Not used.
147	Near Carey, sec. 14, T. 1 S., R. 21 E.	Condie Hot Springs	do	124	450	174	2 springs; bathing pool and irrigation.
	Clark County						
148	10 miles south of Edie, sec. 25, T. 11 N., R. 32 E., Lemhi National Forest.		Carboniferous limestone	80	3,000	174	2 springs; not used.
149	18 miles west of Dubois, sec. 34, T. 10 N., R. 33 E.		Carboniferous limestone overlain by Tertiary lava.	Hot		174	1 spring; not used.
150	16 miles west of Dubois, sec. 2, T. 9 N., R. 33 E., Lemhi National Forest.	Lidy Hot Springs	Faulted rhyolite overlying Carboniferous rocks.	124	300	174	Several springs; bathing pool and irrigation.
	Fremont County						
151	Near Warm River, NE¼ sec. 6, T. 9 N., R. 44 E., Targhee National Forest.		Tertiary lava	Warm	50	174	3 springs; not used.
	Madison County						
152	South Fork of Snake River at Heise, SE¼ sec. 25, T. 4 N., R 40 E., Targhee National Forest.	Heise Hot Spring	Faulted lava	120	400	65, p. 32; 174	1 spring; resort.
	Teton County						
153	6 miles south of Canyon City, sec. 6, T. 5 N., R. 43 E., Targhee National Forest.	Pincock Hot Spring	Paleozoic limestone	Hot	65	174	1 spring; resort. Formerly Lime Kiln Hot Spring.
	Bonneville County						
154	Fall Creek, 4 miles northwest of Irwin, sec. 29, T. 1 N., R. 43 E.		Faulted Paleozoic rocks	Warm		65, p. 32	Several springs; local use.
155	East side of South Fork of Snake River, 5 miles northwest of Alpine, secs. 18 and 19, T. 2 S., R. 46 E.	Alpine Hot Springs	Carboniferous limestone	120–150	25	174	2 main springs; several smaller ones; resort. Sulphur odor; tufa deposit.
156	West side of South Fork of Snake River 3 miles southwest of Blowout, secs. 13 and 24, T. 2 S., R. 45 E.		Faulted limestone; probably Carboniferous.	88–144		65, p. 33; 143, p. 325	6 springs; bathhouse.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

Data on thermal springs in the United States—Continued

Idaho—Continued

[See pl. 11]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Bingham County						
157	3 miles southeast of old Fort Hall, sec. 36, T. 3 S., R. 37 E.	Lincoln Valley Warm Springs.	Limestone, probably Carboniferous.	69-87		166, p. 150; 169, p. 182.	5 springs; local use.
	Owyhee County						
158	Enterprise, T. 1 N., R. 3 W.		Lake sediments of Payette formation; artesian structure.	128	3,000	60, p. 27; 61, p. 5	1 spring; bathing, irrigation.
159	South side of Snake River, near mouth of Reynolds Creek, T. 1 S., R. 3 W.	Given's Hot Springs	Miocene sediments near Tertiary lava.	98	35	169, p. 181; 171, p. 223; 173, p. 345.	2 springs; bathing.
159a	Toy ranch, sec. 29, T. 5 S., R. 1 E.	(²)	Alluvium	115-120	50	174	Several springs; bathing.
160	Shoofly Creek, near Grand View, sec. 14, T. 6 S., R. 3 E.		Lake beds of Payette formation (Tertiary).	Warm	300	174	2 springs; irrigation; tufa deposits.
161	Little Valley Creek, 10 miles southeast of Comet, NE¼ sec. 32, T. 6 S., R. 5 E.	Rosebrier Spring	Valley alluvium; near fault in lake beds of Payette formation.	101	Small	59, p. 169; 68, p. 36	Local use; original flow increased by drilled well.
162	Near head of Little Valley Creek, SE¼ sec. 24, T. 7 S., R. 4 E.		Lake beds of Payette formation.	99	135	68, p. 36	1 spring; irrigation; original flow, 25 gallons a minute, increased by 5 drilled wells.
163	West side of Bruneau Valley near Hot Springs post office, SE¼ sec. 21, T. 7 S., R. 6 E.	Bruneau Hot Spring	Miocene sediments; artesian structure, or fault.	105	1,200	59, p. 167; 60, p. 27; 68, p. 37.	Bathing; irrigation.
164	Bruneau Valley, SW¼ sec. 22, T. 7 S., R. 6 E.		Lake beds of Payette formation.	111	35	68, p. 37	1 spring; local use.
165	Bruneau Valley, SE¼ sec. 22, T. 7 S., R. 6 E.	Trammel's Hot Springs	Alluvium; near fault in lake beds of Payette formation.	114	1,000	68, p. 37	Bathhouse, bathing pool, irrigation.
166	East bank of Bruneau River, NW¼ sec. 35, T. 7 S., R. 6 E.		Probably from Payette formation.	Warm	Large	68, p. 38	1 spring; not used.
167	11 miles south of Bruneau, lot 3, sec. 3, T. 8 S., R. 6 E.	Hot Creek Springs	Issue from tuff beneath basalt.	94-98	1,800	68, p. 37	Several springs; irrigation.
168	Bruneau Valley, below mouth of Hot Creek, lot 1, sec. 3, T. 8 S., R. 6 E.		Tuff in Payette formation	100		68, p. 38	Several springs; local use.
169	Bruneau Valley, 100 yards below Buckaroo diversion dam, SW¼ sec. 29, T. 8 S., R. 7 E.		Issues in river bed from Payette formation.	105		68, p. 38	1 spring; not used.

169a	West Fork of Bruneau River, sec. 33, T. 12 S., R. 7 E.	Indian Hot Springs [1]	Rhyolite beneath basalt	145–158	2,000	174	2 principal springs; bathing. In canyon 950 feet deep. Also called Bat Hot Springs.
169b	10 miles southwest of Three Creek	Kitty's Hot Hole [2]	Basalt	Hot	Small	174	Bathing.
	Gooding County						
170	Near Blanche, sec. 31, T. 4 S., R. 13 E.	White Arrow Hot Spring	Pliocene lava	149	1,200	174	4 springs; bathing pool; irrigation.
171	1½ miles northeast of White Arrow Springs, T. 4 S., R. 13 E.	Blanche Crater Warm Springs.	Quaternary lava	80	Small	174	Supply Soda Lake (Lye Lake) covering 3 acres in the crater; not used.
172	2 miles southeast of White Arrow Hot Springs.	Tschannen Warm Springs.	Pliocene lava	110		174	Seepage forms a small meadow; drilled well has artesian flow of 200 gallons a minute of hot water; local use.
	Twin Falls County						
173	South side of Snake River, on island in Salmon Falls Creek near Austin, sec. 30, T. 8 S., R. 14 E.		Tertiary lake beds overlying lava.	130	5	174	1 spring; bathing.
174	South side of Snake River near Austin, sec. 31, T. 8 S., R. 14 E.	Ring's Hot Spring	Faulted Tertiary lake beds	125	200	174	Forms a pool, bubbling with odorless gas; local use.
175	South bank of Snake River, 4 miles above mouth of Salmon River, sec. 33, T. 8 S., R. 14 E.	Banbury Hot Springs	Recent alluvium near fault in Tertiary lake beds.	131	600	59, p. 169; 174	2 springs improved by drilled well; bathing pool, irrigation.
176	Canyon of Salmon River, 8 miles above junction with Snake River, about T. 9 S., R. 13 E.	Poison Spring	Tertiary lava	Warm	Small	59, p. 169	Not used.
177	Rock Creek, 10 miles south of Stricker, SE¼ sec. 10, T. 13 S., R. 18 E.		do	90	1,300	174	3 springs; not used.
178	Artesian City, sec. 6, T. 12 S., R. 20 E.	Artesian City Hot Springs.	Alluvium, near fault in underlying lava.	100	Small	174	Original flow increased by several wells drilled in 1909, flowing water at 260 feet; total 500 gallons a minute; bathing pool and irrigation.
179	9 miles northwest of Oakley, NE¼ sec. 6, T. 13 S., R. 21 E.	Poulton Warm Spring	Issues from fault fissures in Paleozoic limestone.	72		66, pp. 61, 63*	Local use; original flow increased by wells drilled at spring.
180	6 miles northeast of Oakley, sec. 7, T. 13 S., R. 23 E.	Land Spring	Issues at base of rhyolite, along faulted border of valley.	60	2,000	66, pp. 58, 63*	Irrigation.
181	½ mile south of forks of Thoroughbred Creek, SW¼ sec. 21, T. 16 S., R. 19 E.	Thoroughbred Springs	Late Miocene sediments, underlain by faulted Paleozoic rocks.	69	200	66, p. 62	Several springs; local use.
182	5 miles south of Oakley, SE¼ sec. 27, T. 14 S., R. 22 E.	Oakley Warm Spring	Paleozoic quartzite	114	10	66, pp. 61, 63*	Flowing well drilled near original spring; local use.
183	1 mile southwest of Elba, sec. 6, T. 14 S., R. 25 E.		Carboniferous rocks	Warm		174	1 spring; not used.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.
[2] Not shown on pl. 8.

Data on thermal springs in the United States—Continued

Idaho—Continued

[See pl. 11]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Twin Falls County—Continued.						
184	5 miles southwest of Bridge, sec. 23, T. 15 S., R. 26 E.	Frazier Hot Spring	Alluvium, near fault in Carboniferous rocks.	204	120	174	Original seeping spring developed by well 400 feet deep; irrigation.
185	6 miles northeast of Albion, sec. 11, T. 11 S., R. 25 E.	Bridger Hot Spring	Faulted Eocene lake beds	120	4	174	Stock water; 3 flowing wells of warm water nearby.
186	4 miles northeast of Albion, sec. 22, T. 11 S., R. 25 E.		do	100	3	174	1 spring; stock water.
	Power County						
187	Lake Walcott, sec. 19, T. 9 S., R. 28 E.		Lake sediments along fault	70	700	174	5 springs; not used.
188	8 miles northeast of Yale, sec. 29, T. 9 S., R. 29 E.	Fall Creek Warm Springs.	Carboniferous limestone at faulted contact with lake sediments.	62	9,000	174	Several springs; not used. Deposits tufa in creek channel.
189	South side of Snake River, 4 miles southwest of American Falls, sec. 19, T. 8 S., R. 31 E.	Indian Hot Springs	Faulted Paleozoic limestone.	140	1,000	174	Several springs; resort, bathing.
	Bannock County						
190	Both sides of Portneuf River, 2 miles south of Lava, T. 9 S., R. 38 E.	Lava Hot Springs	Faulted quartzite and tufa	100–144	4,200	174	Several springs; resort, also State bathhouse.
190a	6 miles northwest of McCammon	(2)	Lava	Warm	Small	174	Bathing.
191	West side of Bear River in south end of Gentile Valley, T. 10 S., R. 40 E.		Lava overlying Paleozoic rocks.	125		169, p. 182	5 springs; rise in pools; not used.
191a	4 miles southeast of Downey	Downata Hot Springs	Quaternary gravel	112	470	174	Bathing, irrigation.
	Caribou County						
192	Canyon of Blackfoot River, about T. 6 S., R. 42 E.		Carboniferous limestone and shale.	82	Small	57, p. 562	1 spring; not used; tufa deposit.
193	Soda Springs, T. 9 S., R. 42 E.	Soda Springs	Carboniferous limestone	76–88		57, pp. 590–596; 166, p. 150.	Several springs; some warm and some cool; resort.

	Oneida County						
194	2 miles southwest of Malad, T. 14 S., R. 36 E.		Carboniferous rocks	85		169, p. 182	Several springs; local use.
195	12 miles south of Malad, T. 16 S., R. 36 E.		do	Warm		169, p. 182	Do.
	Bear Lake County						
196	Near northeast shore of Bear Lake, 16 miles south of Montpelier.	Bear Lake Hot Springs	do	83-134	150	163, p. 339; 174	Three springs; resort.
	Massachusetts [See pl. 8]						
	Berkshire County						
1	2 miles south of Williamstown	Sand Spring	Schist of pre-Cambrian age	76	400	169, p. 22; 173, pp. 421-422*; 174.	Used in manufacture of soft drinks for more than 30 years.
	Montana [See pl. 11]						
	Sanders County						
1	Camas, NW¼ sec. 3, T. 21 N., R. 24 W., Flathead Indian Reservation.	Camas Hot Springs	Diorite sill in Belt series (pre-Cambrian); probably faulted.	110-114		80, pp. 20, 29*, 32; 81, p. 823; 173, p. 465*, 174.	7 springs; resort.
2	1 mile west of Camas, sec. 4, T. 21 N., R. 24 W.		Belt series (pre-Cambrian)	Warm		80, p. 29*; 81, p. 623.	1 spring; local use.
3	4 miles south of Paradise, SW¼ sec. 9, T. 18 N., R. 25 W.		Schist and gneiss of Belt series.	114	20	174	7 springs; bathing.
	Missoula County						
4	8 miles southwest of Woodson	Granite Hot Springs	Granite	135	25	169, p. 178; 173, pp. 466-467*; 174.	3 springs; resort; also called Lo-Lo Hot Springs.
	Powell County						
5	Warm Springs Creek, 6 miles north of Garrison.		Folded Cretaceous and Carboniferous rocks.	Warm		169, p. 179	Local use.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.
[2] Not shown on pl. 8.

Data on thermal springs in the United States—Continued

Montana—Continued

[See pl. 11]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Lewis and Clark County						
6	North Fork of Sun River, 30 miles by road west of Augusta.	Sun River Hot Springs	Folded and faulted Cretaceous and Carboniferous rocks.	84	500	77, p. 598; 169, p. 178; 174.	1 main spring; resort; also called Medicine Springs.
7	2 miles west of Helena	Helena Hot Springs	Paleozoic rocks	122, 141	30	75, p. 234; 167, p. 32*; 171, p. 321; 173, pp. 463-464*.	2 springs; resort; bathhouse and pool (Broadwater Natatorium).
	Blaine County						
8	6 miles south of Lodge Pole, NW ¼ sec. 24, T. 26 N., R. 25 E., Fort Belknap Indian Reservation.	Big Warm Springs	Cretaceous shale and limestone on northeast side of area of Tertiary intrusive rock.	72-86	10,000	174	7 springs; local use.
	Phillips County						
9	9 miles south of Lodge Pole, sec. 32, T. 26 N., R. 26 E., Fort Belknap Indian Reservation.	Little Warm Springs	do	Warm	3,500	174	Local use.
	Fergus County						
10	Warm Spring Creek, 12 miles north of Lewistown, NE ¼ sec. 19, T. 17 N., R. 18 E.	Warm Spring	Faulted Kootenai sandstone; may also be artesian structure. Water probably rises from depth of about 1,800 feet.	68	80,000	73, p. 453; 78, pp. 11, 38, 55; 83, p. 82; 174.	Mining, milling, and irrigation; near a large old tufa deposit which indicates formerly warmer water.
11	Durphy Creek, 3 miles south of Tyler, sec. 19, T. 12 N., R. 23 E.		Closely folded shale of the Ellis formation (Upper Jurassic).	71	15,000	174	8 springs in area of several acres; irrigation.
	Ravalli County						
12	Weeping Child Creek, 15 miles southeast of Hamilton.	Medicine Rock Hot Springs.	Granite	Hot	4,500	62, p. 113; 174	Several springs; resort. Formerly Weeping Child Hot Springs.

13	4 miles west of Slate Creek River station, SE¼ sec. 31, T. 1 S., R. 22 W., Bitterroot National Forest.		do	Warm	330	174	5 springs; not used.
14	4 miles south of Camp Creek station, SW¼ sec. 15, T. 1 S., R. 19 W., Bitterroot National Forest.	Gallogly Hot Springs	do	110-125	150	169, p. 179; 174	3 springs; resort; also called Ross' Hole Hot Springs, and Medicine Hot Springs.
	Deer Lodge County						
15	Near Warm Springs railroad station, 10 miles northeast of Anaconda.	Warm Springs	Tertiary sediments overlying granite.	Warm		169, p. 179; 173, pp. 467-468*.	Resort.
16	3 miles east of Anaconda	Anaconda Hot Springs [2]	Travertine underlain by limestone of Mesozoic age, probably Jurassic.	do		77, p. 600; 174	Several springs; local use.
	Silver Bow County						
17	Gregson, 15 miles west of Butte	Gregson Hot Springs	Lava overlying granite			77, p. 599; 169, p. 178.	Several springs; used to heat greenhouses.
	Jefferson County						
18	17 miles south of Helena	Alhambra Hot Springs	Granite	90-134		75, p. 234; 171, p. 317; 173, pp. 461, 462*.	22 springs; resort.
19	3 miles southeast of Boulder	Boulder Hot Springs	Fissured granite	125-187	Large	75, pp. 23*, 234; 77, p. 599; 171, p. 318*; 173, pp. 464-465*.	Many springs; resort.
20	Pipestone Springs, 20 miles southeast of Butte.	Pipestone Springs	Granite	Hot		75, p. 234; 173, p. 467*.	Several springs; resort.
	Broadwater County						
21	North side of Indian Creek, 4 miles northwest of Townsend.	Bedford Springs	Issue from gravel which rests on Tertiary beds; probable source in underlying rocks, pre-Cretaceous to Cretaceous.	74	1,400	82, p. 47	3 main springs; irrigation.
22	Branch of Crow Creek, 5 miles west of Toston.	Warner Warm Springs	Miocene lake-bed deposits	65	200	169, p. 179; 174	2 springs, local use.
23	Head of Warm Creek, 12 miles southwest of Toston.	Plunkett's Spring	Rises from Madison limestone under pressure.	62	4,000	82, p. 47; 174	Irrigation; formerly Nave's Warm Spring and Mockel Spring.
	Meagher County						
24	White Sulphur Springs	White Sulphur Springs	Miocene lake beds overlying calcareous shales of Belt series (pre-Cambrian), near volcanics; fault to east.	95-125	500	70, p. 75*; 71, pp. 149-150*; 74, p. 8*; 171, p. 321; 173, pp. 468-469*.	9 springs; resort. Formerly Brewer's Springs.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.
[2] Not shown on pl. 8.

Data on thermal springs in the United States—Continued

Montana—Continued

[See pl. 11]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Beaverhead County						
25	Big Hole River, at Jackson	Big Hole Hot Springs	Tertiary sediments overlying rocks of the Belt series.	132	1,500	143, p. 325; 169, p. 178.	About 100 springs; resort.
26	Miller Creek, 6 miles north of Polaris, sec. 29, T. 4 S., R. 12 W., Beaverhead National Forest.	Elkhorn Hot Springs	Granite	120–150	110	174	7 springs; resort.
27	Near Apex	Ziegler Hot Springs	Folded Cretaceous and Carboniferous rocks.	Hot		81, p. 885	Local use.
28	9 miles southwest of Dillon, sec. 21, T. 8 S., R. 9 W.	Lovell Springs	Tertiary lava	72	1,125	174	4 springs; local use.
29	11 miles southwest of Dillon, sec. 30, T. 8 S., R. 9 W.	Brown Springs	Carboniferous limestone overlain by Tertiary lava.	72	360	174	6 springs; local use. Also called Ryan Canyon Springs.
	Madison County						
30	Silverstar	Barkel's Hot Springs	Tertiary lake beds overlying granite.	Hot	50	174	4 springs; bathing.
31	South branch of Willow Creek, 5 miles south of Pony.	Clark's Warm Springs	Granite	100–120	550	72, p. 4; 171, p. 321; 174.	About 10 springs; resort. Formerly Potosi Hot Springs.
32	Hot Spring Creek near Norris	Hapgood Hot Springs	Syenite	110–124	50	72, p. 5; 166, p. 150	5 springs; bathing; also called Norris Hot Springs.
33	Upper Ruby Creek, 10 miles northwest of Virginia City.	Puller's Hot Springs	Schist and gneiss of pre-Cambrian age.	95, 108	150	169, p. 179; 171, p. 321; 174.	2 springs; resort.
34	3 miles southwest of Cliff Lake, SE¼ sec. 18, T. 12 S., R. 1 E., Madison National Forest.		Quaternary lava overlying Cretaceous and Carboniferous rocks.	Warm	100	174	1 spring; not used.
	Gallatin County						
35	West Gallatin River, 7 miles west of Bozeman.	Bozeman Hot Springs	Tertiary sediments overlying folded Cretaceous and Carboniferous rocks.	137	250	70, p. 75*; 169, pp. 178, 180*; 171, pp. 318, 319*; 173, pp. 462, 463*; 174.	1 main spring; resort. Formerly Ferris Hot Springs.

	Park County						
36	20 miles northeast of Livingston	Hunter's Hot Springs	Faulted Livingston formation (Upper Cretaceous and Eocene) and volcanic rocks, near dikes.	148-168	1,500	76, p. 74; 77, p. 601; 171, p. 319*; 173, pp. 465-466.	3 groups, about 25 springs; resort for many years. Gypsum deposit.
37	Emigrant Creek near Chico	Emigrant Gulch Warm Springs.	Quaternary lava overlying pre-Cambrian rocks.	102	240	167, p. 31*; 169, pp. 178, 180*.	Bathing; also called Chico Spring.
38	Corwin Springs, sec. 25, T. 8 S., R. 7 E.	Corwin Hot Springs	Pre-Cambrian schist overlain by lava.	120		79, p. 92	Several springs; resort.
39	3 miles northeast of Gardiner, sec. 19, T. 9 S., R. 9 E.	Bear Creek Springs	Pre-Cambrian rocks overlain by Quaternary lava.	90	30	174	2 springs; local use.
	Sweet Grass County						
40	Near Boulder Creek, 3 miles southwest of Hubble, sec. 29, T. 3 S., R. 13 E., Absaroka National Forest.		Cretaceous limestone	70	90	174	1 spring; bathing.

Nevada

[See pl. 15]

	Humboldt County						
1	12 miles west of Pine Forest Range, T. 46 N., R. 27 E.		Near Tertiary lava	108		15, pl. 8	1 spring; not used.
2	North side of Thousand Creek Valley, 6 miles southwest of Denio, Oreg.	Bog Ranch Hot Springs	Granitic rocks (Jurassic intrusives).	130-190	20	15, pl. 8; 169, p. 198.	2 springs; not used.
3	South of Steens Mountain, about T. 47 N., R. 31 E.		do	178		15, pl. 8; 169, p. 198.	Do.
4	12 miles north of Mason's Crossing of Quinn River, about T. 45 N., R. 32 E.		do	118	Small	169, p. 198	1 spring; not used.
5	8 miles north of Quinn River, about T. 44 N., R. 32 E.		do	134	do	15, pl. 8	Do.
6	West side of King River Valley, about T. 45 N., R. 33 E.		Late Tertiary lava	76, 80		15, pl. 8; 169, p. 201	2 springs; local use.
7	Head of North Fork of Little Humboldt River, about T. 45 N., R. 41 E.		Tertiary lava	Hot		169, p. 199	1 spring; not used.
8	Soldier Meadows, 15 miles south of Old Camp McGarry, T. 40 N., R. 25 E.		do	do		169, p. 198	Several springs; not used.
9	West of sink of Quinn River, west edge of Black Rock Desert, T. 40 N., R. 28 E.		Near Tertiary lava	60		84, p. 786; 169, p. 198.	2 springs; prospector's supply.
10	Near south end of Pine Forest Range, 7 miles west of Mason's Crossing of Quinn River, about T. 43 N., R. 31 E.		Tertiary lava	155		169, p. 199	Several springs; not used.
11	12 miles southeast of Paradise Valley post office, on Little Humboldt River.		Valley alluvium	130		15, pl. 8; 174	1 spring; irrigation.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

Data on thermal springs in the United States—Continued

Nevada—Continued

[See pl. 15]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Humboldt County—Continued						
11a	25 miles east of Paradise Valley	(?)	Valley alluvium	Hot		174	Unused; on North and South Forks of Humboldt River.
12	West flank of Black Rock Range, about T. 37 N., R. 24 E.	Double Hot Springs	Tertiary lava overlying granite.	165–191		84, p. 793; 169, p. 198.	Several springs; not used.
13	Southeast side of Black Rock Range, about T. 37 N., R. 25 E.		Tertiary lava	Hot		15, p. 53	Do.
14	Arm of Black Rock Desert, about T. 37 N., R. 26 E.		do	do		15, p. 53	1 spring; not used.
15	Southwest side of Black Rock Range, south of Division Peak, about T. 36 N., R. 24 E.		Granite beneath Tertiary lava.	do		169, p. 199	3 springs; not used.
16	South end of Black Rock Range, 10 miles southeast of Division Peak, about T. 36 N., R. 25 E.		Tertiary lava	do		169, p. 199	Several springs; not used.
17	West border of Black Rock Desert, secs. 16, 21, 22, 34, T. 36 N., R. 26 E.		Quaternary alluvium near lava.	do		94, pl. 1; 169, p. 198; 174.	Several springs; not used.
18	2 miles north of Winnemucca		Jurassic or Triassic rocks	do		166, p. 152	1 spring; local use.
19	Golconda, T. 36 N., R. 40 E.	Golconda Hot Springs	Alluvium	120–150	250	169, p. 198; 174	About 12 springs; resort.
19a	8 miles north of Valmy, sec. 10, T. 35 N., R. 43 E.	Blossom Hot Spring [2]	Alluvium of Humboldt River Valley.	107	70	174	Rises in large deep pool; stock water.
	Elko County						
20	Head of South Fork of Little Humboldt River, about T. 39 N., R. 40 E.		Tertiary lava	Hot		169, p. 199	1 spring; not used.
21	5 miles southeast of Mountain City, SE¼ sec. 30, T. 45 N., R. 54 E., Humboldt National Forest.		Paleozoic limestone	104–106	20	174	4 springs; bathing.
22	15 miles east of Mountain City, sec. 23, T. 46 N., R. 56 E., Humboldt National Forest.		do	104	55	174	Several springs; local use.
23	West side of Goose Creek, NW¼ sec. 22, T. 47 N., R. 68 E.		Paleozoic cherty limestone	57	850	66, p. 62	1 spring; local use.

24	East side of Goose Creek, NW¼ sec. 30, T. 47 N., R. 70 E.	Nile Spring	Alluvium, near Paleozoic rocks.	106	6	66, p. 61	Not used; forms boggy area at edge of Goose Creek Meadow.
25	East side of Goose Creek, SE¼ sec. 10, T. 46 N., R. 69 E.	Gamble's Hole	do	103	8	66, pp. 61, 63*	Do.
26	Head of main fork of Spring Creek, NW¼ sec. 26, T. 46 N., R. 69 E.		Tertiary rhyolite	62	200	66, p. 62	Several springs over area of 1 acre; not used.
27	South end of Thousand Springs Valley, about T. 41 N., R. 69 E.		Carboniferous rocks	Boiling		169, p. 199	1 spring; not used.
28	Hot Creek mining district, 15 miles north of Deeth, T. 39 N., R. 60 E.		Late Tertiary valley fill, near Carboniferous rocks.	Hot		143, p. 325; 166, p. 152.	1 spring; local use.
29	8 miles north of Deeth, sec. 14, T. 38 N., R. 59 E.		Near Tertiary lava	do	Small	174	1 spring; not used.
30	Emigrant Canyon, north end of East Humboldt Range, sec. 21, T. 38 N., R. 62 E.		Faulted Carboniferous rocks	do		169, p. 199	Do.
31	Near Carlin, T. 33 N., R. 53 E	Hot Sulphur Springs	Carboniferous rocks	do		166, p. 152; 169, p. 199.	Several springs; local use.
32	1 mile west of Elko, T. 34 N., R. 55 E	Elko Hot Springs	do	192		143, p. 326; 166, p. 152.	Several springs; resort.
33	8 miles southwest of Fort Halleck, T. 33 N., R. 58 E.		Late Tertiary valley fill, near Carboniferous rocks and Tertiary intrusives.	Warm		169, p. 201	Several springs; local use.
34	Near Warm Creek, Independence Valley, T. 34 N., R. 62 E.		Quaternary alluvium near Carboniferous rocks.	do		143, p. 325; 166, p. 152.	1 spring; local use.
35	Northeast end of Franklin Lake, T. 30 N., R. 59 E.	Miller's Hot Springs	Quaternary alluvium; probably deep faulting.	170		84, p. 541; 169, p. 198.	Several springs; not used.
	Washoe County						
35a	10 miles north of Vya, sec. 18, T. 44 N., R. 20 E.	Hill's Warm Spring [2]	Valley alluvium	83	10	174	Meadow irrigation.
35b	5 miles north of Vya, sec. 11, T. 43 N., R. 19 E.	Hill's Spring [2]	do	66	8	174	Do.
35c	Vya, sec. 4, T. 42 N., R. 19 E	Twin Springs [2]	Tuffaceous lake beds	70	200	174	Irrigation.
36	South end of Surprise Valley, T. 38 N., R. 18 E.		Tertiary lava	Hot		15, pl. 8	1 spring; not used.
37	Northwest end of Alkali Flat, 5 miles northeast of Granite Peak, T. 34 N., R. 23 E.	Ward's Hot Springs (Fly ranch).	Alluvium, near granite mountains.	(6)		84, p. 799; 169, p. 198.	Many springs; cover 75 acres, sandy mounds and tufa deposits. Largest hot springs in northwestern Nevada; irrigation.
38	1 mile northwest of Gerlach	Gerlach Hot Springs	do	188–194		167, p. 24*; 169, pp. 200, 202*.	Many springs; bathing.
39	2 miles west of Gerlach	Mud Springs	do	Hot		15, pl. 8	Several springs; not used.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.
[2] Not shown on pl. 8.
[6] 60° to boiling.

Data on thermal springs in the United States—Continued

Nevada—Continued

[See pl. 15]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Washoe County—Continued						
40	North end of Smoke Creek Desert, sec. 25, T. 33 N., R. 22 E.	Deep Hole Spring	Quaternary lake beds	62	30	15, p. 8	Not used; artesian wells nearby.
41	Northwest side of Smoke Creek Desert, sec. 3, T. 32 N., R. 21 E.	Wall Spring	do	Warm		15, pl. 8	Do.
42	West side of Smoke Creek Desert, about T. 31 N., R. 20 E.	Buffalo Spring	do	do		15, pl. 8	Not used.
43	West side of Smoke Creek Desert, about T. 29 N., R. 19 E.	Buckbrush Spring	do	do		15, pl. 8	Do.
44	Southwest side of Smoke Creek Desert, about T. 29 N., R. 19 E.	Rotten Egg Spring	do	92	10	15, pl. 8; 174	Sulphur odor; not used.
45	Southwest side of Smoke Creek Desert, about sec. 31, T. 29 N., R. 19 E.	Round Hole Spring	do	Warm		15, pl. 8; 174	Not used; artesian wells nearby.
46	South end of Smoke Creek Desert, T. 28 N., R. 20 E.	Ross Spring	Tertiary lava	Hot		15, p. 60; 169, p. 198.	Not used.
47	North end of Pyramid Lake, T. 28 N., R. 21 E.		Tertiary lava over Jurassic rocks.	do		15, p. 220; 169, p. 198.	Several springs; not used.
48	10 miles northwest of Pyramid railroad station, T. 26 N., R. 19 E.	Fish Spring	Tertiary lava	Warm		15, pl. 8	Not used.
49	Northwest side of Pyramid Lake, T. 26 N., R. 20 E.		Faulted Tertiary lava	206–208 [3]		15, p. 60; 169, p. 198.	Several springs; not used.
50	Northwest shore of Winnemucca Lake, T. 27 N., R. 23 E.		Tertiary lava	Warm		15, pl. 8	Do.
51	West shore of Winnemucca Lake, T. 26 N., R. 23 E.		do	do		15, pl. 8	Do.
52	Anaho Island, in Pyramid Lake, T. 24 N., R. 22 E.		do	120		174	Do.
53	Warm Spring Valley, 3 miles south of Dewey, sec. 26, T. 23 N., R. 21 E.	Cottonwood Spring	Granite overlain by Tertiary lava.	Warm		174	Local use.
54	Dead Ox Canyon, east side of Truckee River, 12 miles south of Nixon, T. 21 N., R. 24 E.		Tertiary lava	do		174	1 spring; not used.
55	6 miles west of Reno	Lawton Hot Springs	Faulted granite	120	250	173, pp. 472–473*; 174.	2 main springs; resort, bathing.

55a	10 miles south of Reno	Reno Hot Springs	Granodiorite underlying Tertiary lava.	Boiling		174	Original springs increased by wells; resort, bathing. (Other hot wells 7 miles north at Moana bathing resort.)
55b	10½ miles south of Reno	Radium Steam Baths	do	Boiling	Small	174	Several vapor fissures; bathing.
56	11 miles south of Reno, sec. 33, T. 18 N., R. 20 E.	Steamboat Springs	do	167–203	300	17, p. 979; 45, p. 167; 77, p. 599; 84, p. 825; 85, pp. 338, 353; 88, pp. 275, 278*; 89, pp. 27, 36; 169, p. 200; 173, pp. 373–374*.	Many springs, resort, sanitarium. Large deposit of calcareous and siliceous sinter.
57	10 miles north of Carson City	Bowers Mansion Spring	Granite; at base of Sierra Nevada.	118	20	169, p. 198	Resort; formerly Franktown Hot Spring.
	Storey County						
58	10 miles southwest of Wadsworth, T. 19 N., R. 23 E.		Tertiary lava	73		84, p. 774; 169, p. 201.	1 spring; local use.
	Ormsby County						
59	2 miles north of Carson City	Carson Hot Springs	do	108	65	169, p. 199; 173, p. 473*.	1 principal spring; resort, bathing; formerly Swift's Hot Spring, and Shaw's Hot Spring.
	Douglas County						
60	6 miles northwest of Minden	Walley's Hot Springs	Faulted granitic rock, at base of Sierra Nevada.	136–160	Large	95, p. 189; 169, p. 198; 171, pp. 324*, 325; 173, pp. 474–475*.	Many springs; resort; formerly Genoa Hot Springs.
61	Near Simpson, T. 12 N., R. 23 E	Hund's Hot Springs	Granite	60–140	1,500	169, p. 199	Several springs; resort.
	Lyon County						
62	1 mile north of Wabuska, T. 15 N., R. 25 E.	Wabuska Springs	Near granite underlying Tertiary lava.	138–162		169, p. 200	Several springs; local use.
	Pershing County						
63	North end of Hot Springs Butte, 25 miles southwest of Sulphur, about T. 33 N., R. 26 E.	Butte Spring	Granite	182	20	15, p. 50; 169, p. 198	Not used.
63a	Humboldt River, 2 miles north of Mill City.	(2)	Valley alluvium	Warm	Small	174	Several springs; not used.
64	Grass Valley, 25 miles south of Winnemucca, sec. 35, T. 32 N., R. 38 E.	Leach's Hot Spring	Jurassic or Triassic rocks	118		169, p. 199	1 spring; local use.

1 Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given. 2 Not shown on pl. 8. 3 Boiling.

Data on thermal springs in the United States—Continued

Nevada—Continued

[See pl. 15]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Pershing County—Continued						
65	25 miles south of Winnemucca, sec. 36, T. 32 N., R. 38 E.	Nelson Springs	Jurassic or Triassic rocks	Hot		169, p. 200	Several springs; local use.
66	25 miles southeast of Humboldt, sec. 2, T. 39 N., R. 36 E.	Kyle's Hot Springs	do	do		169, p. 199	Several springs; resort.
67	North end of Salt Marsh Valley, about sec. 1, T. 25 N., R. 36 E.		Near contact of Jurassic or Triassic rocks with underlying granite.	do		94, pl. 1	1 spring; not used.
68	North end of Salt Marsh Valley or Osobb Valley, sec. 29, T. 26 N., R. 38 E.	Sou Hot Springs	Tertiary lava, probably faulted.	160–185		84, pp. 704–707; 169, p. 200.	Group of springs and tufa deposits covering 12 acres; also called Gilbert's Hot Springs; not used.
69	Osobb Valley, 7 miles south of Sou Springs, sec. 26, T. 25 N., R. 38 E.	Cone Spring	Tertiary lava	125	Small	174	Not used; also a similar spring ¼ mile south in sec. 35, across the line in Churchill County.
	Churchill County						
70	Northwest side of Salt Marsh Valley, about T. 24 N., R. 36 E.		Granite, beneath Tertiary lava.	Warm	Small	15, pl. 8	1 spring; not used.
71	Northeast side of Pah Ute Mountains, T. 23 N., R. 35 E.		Alluvium near granite	Hot		169, p. 198	Several springs; not used.
72	56 miles northeast of Reno, sec. 12, T. 22 N., R. 26 E., on U. S. Highway 40.	Springer's Hot Springs	Miocene lake beds, near Tertiary lava.	158–187	10	84, p. 773; 167, p. 24*.	6 springs; bathing; auto station.
73	15 miles northwest of Fallon, T. 20 N., R. 27 E.	Eagle Salt Works Springs	Valley alluvium	Hot		174	Several springs; local use.
74	3 miles east of South Carson Lake, T. 17 N., R. 30 E.	Borax Spring	Valley alluvium, near late Tertiary lava.	178		169, p. 200	Not used.
75	20 miles southeast of Fallon, about sec. 6, T. 16 N., R. 32 E.		Tertiary lava	Hot		169, p. 200	Several springs; sulphur odor; not used.
	Lander County						
76	25 miles north of Battle Mountain, T. 36 N., R. 45 E.	Izzenhood Ranch Springs	do	83	1,000	100, p. 125	Original discharge doubled by trenching, thus lowering water level 4 feet; irrigation.

77	2 miles west of Rock Creek, about sec. 8, T. 33 N., R. 47 E.	White Rock Spring	Late Tertiary lava	Warm		169, p. 200	Local use.
77a	8 miles west of Beowawe, sec. 5, T. 31 N., R. 48 E.	Beowawe Geysers [2]	Tertiary basalt, faulted	100–200	50	143, pp. 322, 325; 174.	About 35 springs on tufa terrace for ¾ mile along fault on hillside; 3 hot springs in lowland nearby. Discharge varies according to season; 2 or 3 springs have true geyser action.
78	Buffalo Valley, 25 miles southwest of Battle Mountain, sec. 24, T. 29 N., R. 41 E.		Tertiary lava	130	5	94, pl. 1; 102, pp. 111, 126, 127*.	Several springs; not used.
79	Reese River Valley, 25 miles south of Battle Mountain, sec. 7, T. 28 N., R. 44 E.	Mound Spring	do	110	3	102, p. 126	Roadside watering.
80	Reese River Valley, 1 mile north of Hot Spring ranch, sec. 23, T. 27 N., R. 43 E.		do	124	450	102, pp. 126, 127*	Several springs; irrigation.
81	Hot Spring ranch, Reese River Valley, sec. 26, T. 27 N., R. 43 E.		do	122	50	102, pp. 126, 127*	Several springs; domestic, irrigation.
82	10 miles south of Lander, T. 27 N., R. 47 E.		Carboniferous rocks with Tertiary intrusives.	Hot		143, p. 376; 166, p. 152.	1 spring; local use.
83	North end of Grass Valley, about T. 22 N., R. 47 E.		Quaternary alluvium near Devonian rocks.	181		169, p. 201	Do.
84	6 miles north of Hot Springs, Smith Creek Valley, T. 18 N., R. 39 E.		Tertiary lava	Warm		169, p. 201	Do.
85	West side of Smith Creek Valley, sec. 25, T. 17 N., R. 40 E.		do	Hot		169, p. 199	Several springs; not used.
86	18 miles southeast of Austin, T. 17 N., R. 46 E.	Spencer Hot Springs	do	117–144	6	101, pp. 91, 153, 154*; 103, p. 299.	Several springs; local use.
87	20 miles southeast of Austin, SE. ¼ sec. 14, T. 16 N., R. 45 E., Toiyabe National Forest.		do	Hot	5	174	7 springs; bathing.
	Eureka County						
88	1 mile northeast of Beowawe	Horseshoe ranch springs [2]	Tertiary lava, faulted	125–132	30	174	2 springs; irrigation, bathing.
88a	Crescent Valley, 12 miles south of Beowawe, sec. 2, T. 29 N., R. 48 E.		Paleozoic rocks, overlain and intruded by Tertiary lava.	122	40	174	2 springs; cattle watering.
89	Head of Hot Creek, 14 miles north of Mineral, sec. 12, T. 28 N., R. 52 E.		Pliocene lake beds, overlying Paleozoic rocks.	84	5,900	174	Group of 6 springs; irrigation.
90	10 miles north of Mineral, sec. 24, T. 28 N., R. 52 E.	Carlotti ranch springs	do	95–102	100	174	2 springs ¼ mile apart; irrigation.
90a	7 miles northeast of Mineral, sec. 14, T 27 N., R 52 E.	Bruffey's Hot Springs	do	108–152	50	169, p. 198; 174	6 springs; domestic, irrigation. Recent tufa deposits of calcium carbonate; old tufa contains bayrite and flurite. Formerly Mineral Hill Hot Springs.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

[2] Not shown on pl. 8.

Data on thermal springs in the United States—Continued

Nevada—Continued

[See pl. 15]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Eureka County—Continued						
91	Diamond Valley, sec. 5, T. 25 N., R. 53 E.	Flynn ranch springs [2]	Alluvium, probably artesian structure.	69-78	10	174	Deep pool and minor springs; irrigation.
91a	Diamond Valley, sec. 6, T. 24 N., R. 53 E.	Siri ranch spring [2]	do	87	300	174	Irrigation.
91b	Diamond Valley, sec. 23, T. 24 N., R. 52 E.	Sadler Springs	Alluvium at base of mountains of faulted Paleozoic rocks.	106	5,000	166, p. 152; 169, p. 199; 174.	Irrigation; formerly Big Shipley Springs.
91c	Diamond Valley, sec. 36, T. 23 N., R. 52 E.	Sulphur Springs ranch springs.[2]	do	74	20	174	Irrigation.
91d	East side of Diamond Valley	Jacobson ranch springs [2]	do	71-75	900	174	Do.
92	West side of Grass Valley, sec. 15, T. 24 N., R. 47 E.		do	Hot	Small	174	Several springs; stock water.
93	East side of Grass Valley, sec. 33, T. 24 N., R. 48 E.		do	do	do	174	Several springs; not used.
93a	Antelope Valley, 35 miles southwest of Eureka, sec. 5, T. 19 N., R. 50 E.	Bartine Hot Springs [2]	Lake beds near mountains of faulted Paleozoic rocks.	105-108	10	174	2 springs on large tufa knoll; artesian well of hot water nearby.
93b	Antelope Valley, 45 miles southwest of Eureka, sec. 28, T. 18 N., R. 50 E.	Clobe Hot Spring	Alluvium near hills of faulted lava.	142	100	174	Stock water.
93c	Head of Fish Creek, sec. 7, T. 16 N., R. 53 E.	Sara ranch springs	Alluvium, probably artesian structure.	66	4,000	174	About 20 deep pools in area ½ mile in diameter; irrigation.
	White Pine County						
94	North end of Schell Creek Mountains, 15 miles southeast of Currie, sec. 27, T. 26 N., R. 65 E.	Collar and Elbow Spring	Valley alluvium	92	20	104, pp. 44*, 49	Not used; tufa deposit.
95	Near Egan Canyon 1¼ miles southwest of Cherry Creek railroad station, T. 23 N., R. 63 E.	Cherry Creek Hot Springs	Valley alluvium near Paleozoic rocks.	118-135	40	104, p. 48	3 springs; bathing.
96	1¼ miles southwest of Cherry Creek railroad station, T. 23 N., R. 63 E.	Schellbourne Hot Springs	do	124		104, pp. 43*, 48	2 springs; bathing, irrigation.
97	Steptoe Valley, 6 miles north of Melvin, sec. 16, T. 22 N., R. 63 E.	Borchert John Spring	Talus slopes of mountains	66	800	104, pp. 43*, 49	Irrigation.

98	1 mile northwest of Warm Springs station, sec. 24, T. 21 N., R. 63 E.	Monte Neva Hot Springs	Valley alluvium near Paleozoic rocks.	173–193	200	104, pp. 43*, 47; 174	6 springs; resort, bathing. Mound of siliceous sinter, ¼ mile in diameter. Formerly Goodrich Hot Springs and Melvin Hot Springs.
99	East base of Kern Mountains, about T. 21 N., R. 70 E.		Faulted Paleozoic rocks	Warm		166, p. 151	1 main spring; not used.
100	10 miles northwest of McGill, SW¼ sec. 5, T. 19 N., R. 63 E.		Paleozoic rocks	58–76	200	104, pp. 44*, 47	Several springs; irrigation.
101	Near McGill, sec. 21, T. 18 N., R. 64 E	McGill Warm Springs	Valley alluvium near Paleozoic rocks.	76–84	450	104, 43*, 46	Do.
102	1½ miles northeast of Ely, sec. 10, T. 16 N., R. 63 E.	Ely Warm Spring	do	85	23	104, p. 46	Bathing.
102a	Newark Valley, T. 23 N., R. 56 E	Moore's ranch springs [2]	Alluvium, probably artesian structure.	65–70	200	174	Irrigation.
103	North end of White Pine Valley, sec. 23, T. 14 N., R. 56 E.	Big Blue Spring	Paleozoic rocks	Warm		169, p. 201; 174	Bathing.
103a	12 miles northwest of Preston, sec. 33, T. 13 N., R. 60 E.	Williams Hot Spring [2]	Tertiary lava	124	50	174	Do.
104	Preston, sec. 1, T. 12 N., R. 61 E	Preston Springs	Valley alluvium near Paleozoic rocks.	Warm	5,700	97, p. 249; 98, pp. 26, 55.	Several springs; irrigation, domestic.
105	Lund, sec. 33, T. 12 N., R. 62 E	Lund Spring	do	do	2,400	97, p. 249; 98, pp. 26, 55.	Municipal water supply.
106	Near Geyser, in south end of Spring Valley, T. 11 N., R. 65 E.	Warm Sulphur Springs	Paleozoic rocks	do		166, p. 152; 169, p. 201.	Several springs; local use.
107	Snake Valley, T. 11 N., R. 69 E., 15 miles south of Baker.	Big Spring	Gravel near cliff of Cambrian limestone.	64	8,000–12,000	83, p. 87; 127, p. 129.	Irrigation.
107a	Head of Big Springs Creek, sec. 30, T. 10 N., R. 70. E.	(2)	Alluvium	Warm	2,000	174	Do.
	Mineral County						
108	3 miles north of Walker Lake, 6 miles east of Schurz, T. 13 N., R. 29 E.	Double Spring	Tertiary lava	do		15, pl. 8; 169, p. 198	Not used.
109	East Walker River, 20 miles west of Hawthorne, sec. 4, T. 7 N., R. 27 E.		Granitic rocks and Tertiary lava.	Hot		174	Several springs; public reserve, bathing.
110	Sodaville, T. 6 N., R. 35 E		Near Jurassic or Triassic rocks overlain by Tertiary lava.	do		99, p. 171	Several springs; local use.
	Esmeralda County						
111	Silver Peak, NE¼ sec. 22, T. 2 S., R. 39 E.	Waterworks Springs	Near Tertiary lava	69–118	500	87, p. 257; 90, p. 161; 96, p. 332; 101, pp. 143, 153*.	11 springs; town water supply.
112	11 miles northwest of Goldfield, NE¼ sec. 26, T. 1 S., R. 41 E.	Alkali Spring	Alluvium near Paleozoic rocks.	120–140	50	92, p. 19*; 93, p. 143*; 101, pp. 149, 153, 154*.	Not used; tufa deposit.

[1] Numbers correspond to numbers of bibliography; asterisk indicates that analyses of the water are given.

[2] Not shown on pl. 8.

Data on thermal springs in the United States—Continued

Nevada—Continued

[See pl. 15]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Nye County						
113	West side of Gabbs Valley, sec. 7, T. 12 N., R. 34 E.		Tertiary lava	Hot		166, p. 152; 169, p. 199.	1 spring; not used.
114	1 mile east of McLeod's ranch, Big Smoky Valley, T. 14 N., R. 43 E.		Alluvium near Paleozoic rocks.	do		101, p. 88	On large mound; not used.
115	Near Millett, Big Smoky Valley, T. 14 N., R. 43 E.	Gendron Spring	do	61	10	101, pp. 88, 153, 154*.	Local use.
116	Near Charnock ranch, Big Smoky Valley, T. 13 N., R. 44 E.	Charnock Springs	Alluvium near Tertiary lava	80	450	101, pp. 91, 154	Several springs; irrigation; also called Big Blue Springs.
117	Big Smoky Valley, 14 miles south of Millett, sec. 14, T. 11 N., R. 42 E.		Faulted Tertiary lava	Boiling	600	169, p. 199	1 spring; local use.
118	Darrough ranch, Big Smoky Valley, NW ¼ sec. 17, T. 11 N., R. 43 E.	Darrough Hot Springs	Alluvium near Paleozoic rocks.	160–198	175	101, pp. 89, 153, 154*; 105, p. 300.	Several springs; resort.
119	2 miles southeast of Potts, sec. 1, T. 14 N., R. 47 E.		Tertiary lava	Warm		174	Several springs; local use.
120	5 miles south of Potts, sec. 22, T. 14 N., R. 47 E.	Diana's Punch Bowl	Quaternary alluvium near Tertiary lava.	Hot	Small	174	1 main spring; not used.
121	Fish Spring Valley, secs. 26 and 35, T. 11 N., R. 49 E.	Fish Springs	Tertiary lava	Warm		169, p. 201	Several springs; local use.
122	5 miles north of Duckwater, sec. 32, T. 13 N., R. 56 E.		Valley alluvium, artesian structure.	do	Large	174	Several springs; irrigation.
123	Near San Antonio, T. 7 N., R. 42 E.	Indian Springs	Near Tertiary lava overlying Paleozoic rocks.	do		166, p. 152	3 springs; local use.
124	Hot Creek, 8 miles northeast of Tybo, T. 7 N., R. 51 E.		Paleozoic rocks overlain by Tertiary lava.	do		174	Several springs; not used.
125	South end of Hot Creek Valley, T. 4 N., R. 50 E.		Silurian and Ordovician rocks, beneath Tertiary lava.	Boiling		169, p. 199	2 springs; not used.
126	West side of Railroad Valley, 20 miles southwest of Currant, sec. 15, T. 8 N., R. 55 E.	Lock's Springs	Valley alluvium near Tertiary lava, probably faulted.	93–99	2,000	174	4 springs; domestic, irrigation; 2 springs issue in pools on large terrace of tufa; 2 issue in meadow at base of terrace.
127	Railroad Valley, 6 miles south of Lock's Springs, sec. 16, T. 7 N., R. 55 E.	Chimney Springs	do	130–160	100	174	3 springs; stock water; issue from large mounds of iron-stained tufa.

128	East side of Railroad Valley, 18 miles south of Currant, sec. 11, T. 8 N., R 57 E.	Blue Eagle Springs	Valley alluvium; artesian structure.	82	1,385	98, p. 30; 174	2 main springs; irrigation.
129	¾ mile south of Blue Eagle Springs, sec. 14, T. 8 N., R. 57 E.	Kate Spring	do	73	14	174	Domestic, irrigation.
130	East side of Railroad Valley, sec. 27, T. 8 N., R. 57 E.	Butterfield Springs	do	64	227	174	2 springs; irrigation.
131	East side of Railroad Valley, sec. 34, T. 8 N., R. 57 E.	Bacon Springs	do	57	2	174	2 seeping springs; stock water.
132	East side of Railroad Valley, sec 28, T. 7 N., R. 57 E.	Bullwhacker Spring	do	59	10	174	Stock water.
133	East side of Railroad Valley, sec. 5, T. 6 N., R 57 E.	Willow Springs	do	60	30	174	2 seeping springs; stock water.
134	5 miles west of White River, sec. 33, T. 9 N., R. 61 E.	Mormon Springs	do	100	100	174	Several springs; irrigation.
135	Near White River, T. 9 N., R. 62 E	Riordan ranch springs	do	70	200	174	Several springs; irrigation. Formerly Emigrant Springs.
136	White River Valley, near Sunnyside, secs. 28, 31 and 32, T. 7 N., R. 62 E.		do	65-75	2,000	98, pp. 26, 56; 169, p. 201.	6 springs; irrigation; on Whipple and Hendricks ranches. Formerly Flag Springs.
137	White River Valley, 8 miles southwest of Sunnyside, sec. 18, T. 6 N., R. 61 E.	Hot Creek ranch springs	do	85-90	5,000	98, p. 26; 128, p. 30*; 169, p. 200.	Several springs; irrigation.
138	5 miles north of Beatty, T. 11 S., R. 47 E.	Hicks Hot Springs	Paleozoic rocks, overlain by Tertiary lava.	110	40	92, p. 20	5 springs; resort.
139	Ash Meadow, sec. 22, T. 17 S., R. 50 E		Valley alluvium near Cambrian rocks.	76-94	450	92, p. 20; 169, p. 201.	4 springs; not used.
140	Pahrump ranch, sec. 14, T. 20 S., R. 53 E.	Pahrump Springs	Valley alluvium near folded and faulted Paleozoic rocks.	77	2,200	86, p. 165; 91, p. 166; 103, pp. 63, 76.	2 main springs; irrigation.
141	Manse ranch, sec. 3, T. 21 S., R. 54 E	Manse Springs	Valley alluvium near faulted Paleozoic rocks.	75	1,500	103, pp. 63, 77, 80*.	2 springs; irrigation.
	Lincoln County						
142	5 miles east of Patterson, T. 8 N., R. 65 E.	Geyser ranch springs	Valley alluvium near Tertiary lava.	65-70	50	166, p. 152; 169, p. 200.	Several springs; irrigation.
143	Hammond ranch, T. 5 N., R. 70 E		Paleozoic limestone	84		98, p. 49	Do.
144	9 miles west of Panaca, T. 2 S., R. 66 E.	Bennetts Springs	Valley fill near Paleozoic limestone.	70	Small	98, p. 51	2 springs; stock water.
144a	10 miles north of Panaca	Delmue's Springs [2]	Tertiary lava	70	200	174	Irrigation; other warm springs on Flatnose ranch nearby.
145	Panaca, sec. 4, T. 2 S., R. 68 E	Panaca Spring	Faulted Paleozoic rocks	85-88	2,500	98, pp. 30*, 50; 174	Municipal water supply.
146	¼ mile north of Caliente, T. 4 S., R. 67 E.	Caliente Hot Spring	do	110		174	Bathhouse and pool; formerly flowed, later pumped.
147	6 miles north of Hiko, sec. 22, T. 4 S., R. 60 E.	Hiko Spring	Fault in Paleozoic limestone	90	4,000	15, pp. 26, 30*; 83, p. 87; 169, p. 201.	Domestic, irrigation.
148	1 mile northwest of Hiko	Crystal Spring	do	90	9,000	83, p. 87	Do.
149	4 miles south of Hiko	Ash Spring	do	90-97	9,000	83, p. 87	Domestic, irrigation; 6 main springs.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

[2] Not shown on pl. 8.

Data on thermal springs in the United States—Continued

Nevada—Continued

[See pl. 15]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Clark County						
150	3 miles west of Moapa, T. 14 S., R. 65 E.		Paleozoic limestone	90		98, p. 61; 128, p. 26	Several springs; bathing, irrigation.
151	1 mile south of Indian Spring railroad station, sec. 16, T. 16 S., R. 56 E.	Indian Spring	do	78	410	86, p. 165; 91, p. 166; 98, pp. 30*, 73.	Railroad use and irrigation.
152	2 miles west of Las Vegas, T. 20 S., R. 61 E.	Las Vegas Springs	Pleistocene sediments with recent volcanic activity, or deformation.	73	2,600	97, pp. 26, 30*, 39; 169, p. 199.	2 springs; domestic, industrial, irrigation.

New Mexico

[See pl. 13]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	San Juan County						
1	10 miles south of Shiprock, about sec. 32, T. 11 N., R. 2 W.		Mancos shale intruded by porphyry dike.	68	3	108, p. 305*; 166, pp. 625–626*; 169, p. 195*.	1 spring; stock water; sulphur odor.
2	5 miles north of Newcomb, about sec. 8, T. 7 N., R. 2 W.		Sandstone and shale intruded by porphry dike.	65	3	174	1 spring; stock water, faint sulphur odor.
3	4 miles north of Newcomb, about sec. 16, T. 7 N., R. 2 W.		do	67	7	174	Do.
	Rio Arriba County						
4	¾ mile northwest of La Madera, SE¼ sec. 23, T. 25 N., R. 8 E.		Tertiary lake beds near granite.	80	10	174	Several springs; not used.
5	1 mile northeast of La Madera, SE¼ sec. 24, T. 25 N., R. 8 E.		Granite	(?)	5	174	Do.
6	¼ mile north of La Madera, NW¼ sec. 25, T. 25 N., R. 8 E.		Tertiary lake beds near granite.	90	15	174	1 spring; not used.
7	1 mile southwest of La Madera, NE¼ sec. 35, T. 25 N., R. 8 E.		Granite	(?)	5	174	Do.

	Taos County						
8	12 miles northwest of Barranca	Ojo Caliente Springs	Gneiss with mineralized dikes.	98–113	350	107, p. 114*; 108, p. 290*; 109, p. 73*; 110, pp. 22–27*; 166, pp. 624, 625*; 171, p. 335*; 173, pp. 489–491*.	5 springs; resort; tufa deposit.
	McKinley County						
9	20 miles east of Tohatchi, about sec. 33, T. 19 N., R. 15 W.	Togay Springs	Probably artesian, rising from Mesaverde formation from depth of 300 to 500 feet.	65	20	174	Many small pools; stock water; formerly more active.
	Sandoval County						
10	15 miles north of Jemez Springs, sec. 29, T. 20 N., R. 3 E.	Murray Spring	Late Tertiary lava	130	150	174	Not used.
11	San Antonio Creek, 20 miles north of Jemez Springs, sec. 7, T. 20 N., R. 4 E.	San Antonio Springs	Tertiary basalt	120	50	111, p. 10; 174	1 spring; not used.
12	12 miles north of Jemez Springs, sec. 3, T. 19 N., R. 3 E.	Sulphur Springs	Tertiary andesite and rhyolite.	80–167	500	108, p. 300; 111, pp. 9, 26, 37–42*; 113, pp. 78*, 88.	About 8 springs; not used; sulphur odor.
13	2 miles north of Jemez Hot Springs, about sec. 15, T. 18 N., R. 2 E.	Soda Dam Springs	Faulted contact of pre-Cambrian granite and Carboniferous limestone.	75–105	10	111, pp. 26, 35*; 174	Several springs; not used. Large tufa deposit in channel of Jemez River.
14	7 miles north of Jemez Springs, SE¼ sec. 4, T. 18 N., R. 3 E.	McCauley Spring	Late Tertiary lava	(7)	110	174	Not used.
15	12 miles north of Jemez, about sec. 22, T. 18 N., R. 2 E.	Jemez Hot Springs	Faulted Permian red beds	94–168	200	108, p. 299*; 109, p. 71; 111, pp. 7, 25, 32–34*; 113, pp. 78*, 88; 166, p. 613; 169, pp. 194, 195*; 171, p. 336; 173, pp. 486–488*.	2 groups of about 10 and 40 springs; resort.
16	1 mile northeast of Rio Salado and 8 miles west of Jemez Pueblo, T. 16 N., R. 1 W.	Phillips Springs	Faulted contact of Permian red beds with Carbonaceous limestone and Chinle shale (Triassic).	70	8	111, pp. 4, 5; 113, pp. 78*, 87, 88.	About 40 springs, cover 30 acres; unused. Travertine mounds of extinct springs.
17	2 miles north of San Ysidro, T. 16 N., R. 2 E.	Indian Springs	Faulted Permian red beds	120		111, p. 6; 113, pp. 78, 86.	Several springs; local use.
18	7 miles southwest of San Ysidro, sec. 8, T. 15 N., R. 1 E.	San Ysidro Hot Springs	Faulted Triassic beds	85		108, p. 300*; 111, p. 5; 113, pp. 78*, 87; 174.	About 40 springs; local use, strongly carbonated.
19	5 miles southwest of San Ysidro, secs. 3, 9, 10, T. 15 N., R. 1 E.	San Ysidro Warm Springs	Faulted crest of anticline in Chinle shale.	68		113, pp. 78*, 86, 87; 173, pp. 492–493*.	Several springs; unused.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

[7] About 100°.

Data on thermal springs in the United States—Continued

New Mexico—Continued

[See pl. 13]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	San Miguel County						
20	6 miles northwest of Las Vegas	Las Vegas Hot Springs	Near contact of pre-Cambrian and Carboniferous rocks.	80–140	100	35, pp. 164, 219; 106, pp. 349–351, 405–406*; 108, p. 298*; 109, p. 71; 112, p. 69; 166, p. 623; 169, pp. 194, 195*; 171, p. 334*; 173, pp. 488–489*.	6 springs; bathing. Formerly Montezuma Hot Springs; slight sulphur odor.
	Valencia County						
21	12 miles southwest of Zuni Village, sec. 21, T. 8 N., R. 20 W.	Ojo Caliente Springs	Faulted anticline in Triassic sandstone and shale.	80	500	108, p. 312; 166, p. 155; 169, p. 194; 174.	2 springs; bathing, irrigation.
22	North side of San Jose River, 4 miles southeast of Suwanee railroad station, 2 miles northwest of Quelites village, T. 8 N., R. 2 W.	Quelites Mineral Spring	Issues at foot of bluff of Cretaceous sandstone on anticlinal structure.	80	3	173, pp. 491–492*; 174.	Local use; tufa deposit.
	Socorro County						
23	1½ miles southwest of Socorro	Socorro Warm Springs	Tertiary lake beds lying against lava hills.	93	500	108, p. 305	Several springs; water supply of Socorro.
24	15 miles northwest of Monticello, sec. 31, T. 8 S., R. 7 W., Datil National Forest.	Ojo Caliente [2]	Rhyolite lava	85	1, 200	108, p. 312; 169, p. 194; 174.	1 large and 6 small springs; not used.
	Catron County						
25	1 mile south of Pleasanton, SW¼ sec. 23, T. 12 S., R. 20 W.		Late Tertiary lava	80–124	50	174	8 springs; local use.
26	1 mile south of D D Bar ranch, NW¼ sec. 30, T. 11 S., R. 12 W.		Quaternary lava agglomerate	80	50	174	1 spring; not used.

27	Diamond Creek near its mouth, about sec. 19, T. 12 S., R. 13 W.		Tertiary lava	151	30	108, p. 311; 166, p. 153; 169, p. 194.	Do.
	Grant County						
28	Sec. 26, T. 13 S., R. 16 W		do	80	20	174	Do.
29	Turkey Creek, 3 miles above its junction with Gila River, sec. 3, T. 14 S., R. 16 W.		Late Tertiary lava	Hot	20	174	Do.
30	Upper Gila River near Diamond Creek, sec. 5, T. 13 S., R. 13 W.	Gila Hot Springs	Tertiary lava	90–100	900	108, p. 310; 166, p. 152; 169, p. 194.	4 springs; bathing.
31	Gila River, sec. 3, T. 13 S., R. 13 W		do	Hot	30	174	1 spring; local use.
32	Gila River, sec. 20, T. 13 S., R. 13 W		do	do	30	174	1 spring; not used.
33	Gila River, sec. 16, T. 14 S., R. 14 W		do	do	20	174	Do.
34	4 miles northwest of Mimbres	Hudson's Hot Springs	Lava	142		169, p. 194; 171, pp. 333*, 334.	Several springs; bathing.
35	7 miles north of Whitewater	Apache Tejo Warm Springs.	Valley alluvium near lava	97	2,000	166, p. 152; 169, p. 194.	Several springs; developed by county.
36	6 miles northeast of Faywood, T. 20 S., R. 11 W.	Faywood Hot Springs	Issue at base of lava slope, in top of calcium carbonate mound 20 feet high, 60 feet in diameter.	142	120	39, p. 122; 108, p. 295*; 109, p. 71.	Several springs; resort, bathing.
	Sierra County						
37	Hot Springs	Hot Springs [2]	Issue from limestone underlying Pennsylvanian sandstone, faulted against granite.	90–105	10	173, pp. 485–486*; 174.	Several springs; resort. Formerly Palomas Hot Springs. About 15 bathing establishments get warm water from wells drilled about 100 feet deep. Site of State hospital for crippled children.
	Dona Ana County						
38	Near Radium Springs railway station, 17 miles north of Las Cruces.	Radium Hot Springs [2]	Issue at base of rhyolite hill, on east border of lowland of the Rio Grande.	165, 185		169, p. 194; 171, p. 336; 174.	2 springs excavated as shallow wells; resort. Formerly Selden Hot Springs. Supply water for baths and heating hotel. Sodium chloride is principal salt in solution.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

[2] Not shown on pl. 8.

Data on thermal springs in the United States—Continued

New York

[See pl. 8]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Columbia County						
1	Lebanon Springs, 27 miles southeast of Albany.	Lebanon Warm Spring	Issues from base of gravel beds of drift, near junction of limestone with talc slate. Evidence of a fault and derangement of the strata in the vicinity.	75	500	163, p. 138; 166, p. 150; 169, pp. 28, 35*; 170, p. 74; 171, p. 355; 173, pp. 508–509*.	Resort, well known since colonial times.

North Carolina

[See pl. 8]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Madison County						
1	French Broad River at Hot Springs, 40 miles northwest of Asheville.	Hot Springs	Pre-Cambrian granite and gueiss and Cambrian quartzite and slate near large thrust fault.	92–117	100	9, p. 186; 56, p. 373*; 166, p. 150; 169, pp. 76, 78*; 171, p. 375; 173, pp. 531–533*.	About 20 springs, of which 4 have been developed (96°–106°); issue at river edge; resort.

Oregon

[See pl. 14]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Clackamas County						
1	Sec. 29, T. 2 S., R. 29 E.	Crater Rock Hot Springs	Quaternary andesite	Hot		174	Several small springs; not used.
2	South side of Mount Hood, SW¼ sec. 24, T. 3 S., R. 8½ E., Mount Hood National Forest.	Mount Hood Warm Springs.	Quaternary lava	60–80	25	174	Several small springs in area of 3 acres; resort.

3	Clackamas River, NE¼ sec. 25, T. 6 S., R. 6 E., about 25 miles southeast of Cazadero.		Columbia River basalt	188		115, p. 76	Several springs; local use.
4	Clackamas River, about 27 miles southeast of Cazadero, NW¼ sec. 30, T. 6 S., R. 7 E.	Carey Hot Springs	do	176–196		115, p. 76; 174	Several springs; bathing; sulphur odor; formerly Austin Hot Springs.
5	Hot Springs Creek, 4 miles south of Thunder Mountain, NW¼ sec. 26, T. 7 S., R. 5 E.	Bagsby Hot Springs	do	Hot	50	115, p. 76; 174	8 springs in area of 5 acres; camping ground.
	Marion County						
6	Breitenbush River, 12 miles northeast of Detroit, NE¼ sec. 20, T. 9 S., R. 7 E.	Breitenbush Hot Springs	do	140–198	900	115, p. 76; 174	About 40 springs in 2 groups in area of 10 acres; resort.
	Wasco County						
7	Warm Springs River 9 miles north of Warm Springs Indian Agency, secs. 19 and 20, T. 8 S., R. 13 E.	Warm Springs	Tertiary lake deposits in area of Columbia River basalt.	138–145	Large	171, p. 394; 174	Many springs issue along banks of river for 2 miles; sulphur odor; camp ground.
	Umatilla County						
8	Camas Creek, 50 miles south of Pendleton, SW¼ sec. 1, T. 5 S., R. 33 E., Umatilla National Forest.	Lehman Hot Springs	Columbia River basalt	Scalding	75	174	10 springs; resort.
9	7 miles southwest of Lehman Hot Springs, T. 5 S., R. 33 E., just outside Umatilla National Forest.	Hideaway Springs	do	Hot		174	Several springs; resort; sulphur odor.
	Union County						
10	2 miles northeast of Summerville, about sec. 6, T. 1 S., R. 39 E.		do	Warm		169, p. 216	Several springs; local use.
11	Hot Lake, 10 miles southeast of La Grande, T. 4 S., R. 39 E.	Hot Lake	do	180	175	174	Bathing.
12	20 miles north-northeast of Baker, sec. 24, T. 6 S., R. 41 E.	Medical Springs	Greenstone series (Carboniferous ?).	140	50	114, p. 641*	2 springs; local use.
	Grant County						
13	North bank of Middle Fork of John Day River, near Ritter, sec. 8, T. 8 S., R. 30 E.	Ritter Hot Spring	Fault fissure in crest of broad low dome of Columbia River basalt.	110	35	174	Resort; formerly McDuffee Hot Spring.
14	Camp Creek, 6 miles south of Susanville, sec. 35, T. 10 S., R. 32 E.	Hot Sulphur Spring	Columbia River basalt (Miocene) overlying Carboniferous rocks.	120		114, p. 642; 169, p. 216.	Resort.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

Data on thermal springs in the United States—Continued

Oregon—Continued

[See pl. 14]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Grant County—Continued						
15	Near Canyon Creek, 10 miles south of Canyon City, sec. 11, T. 15 S., R. 31 E., Malheur National Forest.	Bear Gulch Spring	Jurassic or Triassic rocks overlain by late Tertiary lava.	Warm	2	174	Not used.
16	Near mouth of Reynolds Creek, 10 miles southeast of Prairie City, sec. 13, T. 14 S., R. 34 E.	Blue Mountain Hot Springs.	Carboniferous rocks	Hot		114, p. 642	Several springs; local use.
	Baker County						
17	4 miles southeast of Durkee, sec. 2, T. 12 S., R. 43 E.	Sam-O Mineral Springs	Jurassic or Triassic rocks, probably faulted.	80		114, p. 641; 118, pp. 563, 564*.	2 springs; local use.
17a	10 miles northwest of Baker, sec. 28, T. 7 S., R. 39 E.	Radium Hot Spring [2]	Jointed diorite	135		174	Natural flow small; increased many times by 2 flowing thermal wells; bathing.
17b	1 mile east of Baker, sec. 16, T. 9 S., R. 40 E.	Sam-O Spring [2]	Tertiary volcanic and sedimentary rocks overlain by alluvium.	80	400	174	Irrigation.
	Lane County						
18	6 miles east of McKenzie Bridge, sec. 11, T. 16 S., R. 6 E.	Belknap Hot Springs	Late Tertiary lava	150–188	75	115, p. 76; 119, p. 81; 171, p. 393*; 173, pp. 561, 562; 174.	3 main springs; resort.
19	4½ miles southeast of McKenzie Bridge, sec. 28, T. 16 S. R. 6 E.	Foley Springs	do	162–174	25	115, p. 76; 169, pp. 215, 217*; 173, pp. 562, 563*; 174.	4 springs; resort.
20	South Fork of McKenzie River 8 miles southwest of McKenzie Bridge, SE¼ sec. 7, T. 17 S., R. 5 E., Cascade National Forest.		Columbia River basalt	130	60	174	4 springs; not used.
21	10½ miles northeast of Oakridge, NW¼ sec. 26, T. 20 S., R. 4 E., Cascade National Forest.	Wall Creek Hot Springs	do	98	3	174	3 springs; local use.
22	11 miles east of Oakridge, SE¼ sec. 36, T. 21 S., R. 4 E., Cascade National Forest.	Winino Springs	do	Hot	20	174	Group of 15 springs covering 1 acre; resort. Also called McCredie Springs.

23	8 miles southeast of Oakridge, sec. 6, T. 22 S., R. 4 E., Cascade National Forest.	Kitson Springs	do	114	35	174	2 main springs; resort.
	Douglas County						
24	Umpqua River, 5 miles south of Potter Mountain, NW¼ sec. 20, T. 26 S., R. 4 E., Umpqua National Forest.	Umpqua Warm Spring	Tertiary andesite	105	5	174	2 springs; not used.
	Jackson County						
25	2 miles northwest of Ashland	Jackson Hot Springs	Granitic rocks	104	70	174	8 springs; resort.
	Klamath County						
26	Summit Lake Valley, about sec. 31, T. 24 S., R. 5½ E.		Late Tertiary lava	Warm		169, p. 216	Several springs; local use.
27	Klamath Falls	Klamath Hot Springs	do	185	150	174	1 principal group of springs supplies bathing pool. Numerous wells in vicinity supply hot water for heating residences.
28	½ mile northeast of Olene		Tertiary lava	130	8	174	1 spring, domestic; other springs issue in river bed nearby.
28a	2 miles east of Olene	Taylor Warm Spring [2]	do	75	500	174	Irrigation.
28b	1 mile south of Olene	Crystal Springs [2]	do	76	1,350	174	Irrigation; bathing.
29	10 miles southeast of Bonanza, NW¼ sec. 10, T. 40 S., R. 13 E.	Oregon Hot Springs	Tertiary lake beds	148	35	174	Bathing; sanitarium. Formerly Turner Hot Springs.
29a	9½ miles southeast of Bonanza, SW¼ sec. 10, T. 40 S., R. 13 E.	Smith's Hot Spring	do	146	5	174	Bathing; stock water.
29b	13 miles southeast of Bonanza, NE¼ sec. 6, T. 40 S., R. 14 E.	Wilkerson's Warm Springs.[2]	Tertiary lava; artesian structure.	76	20	174	2 springs on lava mound; domestic, irrigation.
30	Horsefly Valley, 8 miles south of Bly, sec. 18, T. 38 S., R. 15 E.	Robertson's Springs	Late Tertiary lava	Hot		169, p. 216	Several springs; local use.
	Deschutes County						
31	North shore of Paulina Lake, NW¼ sec. 26, T. 21 S., R. 12 E., Deschutes National Forest.	Paulina Springs	Late Tertiary andesite lava and tuffs.	65, 70	10	174	2 springs; not used.
32	South shore of East Lake, SW¼ sec. 29, T. 21 S., R. 13 E., Deschutes National Forest.	East Lake Hot Springs	Issue in Tertiary lake sediments, near border of late Tertiary lava flow.	110–141		116, p. 100; 174	Many small springs; bathing.
	Crook County						
33	Spring numbered 33 by error; see no. 75, in Malheur County, p. 177.						
34	Near Twelvemile Creek, 20 miles southwest of Paulina, about sec. 36, T. 19 S., R. 32 E.		do	60–87		116, pp. 55–56	Several springs; local use.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

[2] Not shown on pl. 8.

Data on thermal springs in the United States—Continued

Oregon—Continued

[See pl. 14]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Lake County						
35	5 miles northeast of Fossil Lake, sec. 35, T. 25 S., R. 19 E.	Sand Springs	Valley alluvium over lake sediments.	62	30	117, p. 66	3 springs, the southernmost called Mound Spring; stock water.
36	West shore of Christmas Lake, sec. 32, T. 26 S., R. 18 E.		do	62	3	117, p. 66	1 spring, improved by excavating; domestic supply.
37	7 miles north of Summer Lake post office, sec. 6, T. 30 S., R. 17 E.	Ana River Springs	Water rises through Pliocene lake sediments from faulted basalt.	66	(3)	117, p. 54	5 springs; irrigation.
38	9 miles north of Summer Lake post office, sec. 5, T. 30 S., R. 17 E.	Buckhorn Creek Springs	Lake sediments overlying basalt.	68	1,000	117, p. 54	Several springs; irrigation.
39	12 miles northeast of Summer Lake post office, sec. 34, T. 29 S., R. 17 E.	Johnson Creek Springs	do	56	9,000	117, p. 54	Do.
40	East side of Summer Lake Valley, sec. 19, T. 30 S., R. 18 E.	Thousand Springs	do	66	200	117, p. 54	Many small springs; irrigation.
41	½ mile north of Summer Lake post office, sec. 35, T. 30 S., R. 16 E.	Pardon Warm Spring	Tertiary lake sediments near fault scarp in late Tertiary lava.	76	40	174	Local use.
42	Near south end of Summer Lake, sec. 11, T. 33 S., R. 17 E.	Woodward Hot Spring	Lake sediments overlying basalt.	123	20	117, p. 55	Irrigation, bathing.
43	West shore of Alkali Lake, sec. 12, T. 30 S., R. 22 E.		Valley alluvium over lake sediments.	59	25	117, p. 69	1 spring; domestic, stock water.
44	XL ranch, 3 miles north of Abert Lake, sec. 22, T. 32 S., R. 21 E.		Lake sediments overlying basalt.	63	10	117, p. 51	1 spring; domestic, irrigation.
44a	Northeast shore of Abert Lake, 19 miles north of Valley Falls.	(2)	Lake sediments at base of fault scarf in Tertiary basalt.	65	20	174	Stock water.
44b	East shore of Abert Lake, 17 miles north of Valley Falls.	(2)	do	68	10	174	Do.
44c	Southeast shore of Abert Lake, 12 miles north of Valley Falls.	(2)	do	80	30	174	Do.
44d	10 miles north of Lakeview	White Rock Ranch Springs.	Basalt	63, 71	10	174	2 springs; domestic, irrigation.

45	2 miles north of Lakeview	Hunters Hot Springs	Faulted Pliocene lake beds in region of late Tertiary lava.	128–162	600	117, p. 51; 174	12 main springs; hotel, resort; artesian well ½ mile northeast, 200 feet deep, discharges 120 gallons a minute of boiling water, used to heat hotel.
46	1½ miles south of Lakeview	Leithead Hot Spring (Joyland Plunge).	Late Tertiary lava; water issues at base of fault scarp; secondary quartz.	162	50	169, p. 215; 171, p. 395; 174.	1 spring; bathing; sulphur odor; formerly Lakeview Hot Spring.
47	2 miles south of Lakeview	Barry Ranch Hot Springs	do	175–182	25	117, p. 51; 174	3 springs; irrigation; sulphur odor; formerly Lakeview Hot Springs and Down's Hot Springs.
48	Upper Rock Creek, 4 miles east of North Warner Lake, sec. 16, T. 35 S., R. 26 E.		Coarse tuff interbedded with Miocene lava.	105–115	50	118, pp. 40, 66; 169, p. 215.	Several springs; stock water.
49	North side of Hart Mountain, sec. 7, T. 36 S., R. 26 E.	Hart Mountain Hot Spring.	Gray tuff interbedded with basalt.	Hot		174	About 200 feet below crest of Hart Mountain; stock water.
50	Warner Valley, 1 mile east of Adel post office, sec. 23, T. 39 S., R. 24 E.	Adel Hot Spring	Faulted Tertiary lake sediments.	160	10	174	Local use.
51	Warner Valley, 3 miles east of Warner Lake post office, sec. 27, T. 40 S., R. 24 E.	Houston Hot Springs	Tertiary lake sediments near fault scarp in late Tertiary lava.	160	20	174	4 springs; local use.
	Harney County						
51a	17 miles northeast of Burns, sec. 14, T. 22 S., R. 32½ E.		Alluvium overlying Miocene sediments and associated rhyolite.	72	225	174	Stock water, irrigation.
52	5 miles south of Burns, secs. 35 and 36, T. 23 S., R. 30 E.	Millpond Spring (and others).	Coarse tuffs interbedded with Quaternary basalt.	73–80	1,200	60, p. 39; 118, pp. 35, 39, 56, 63; 174.	3 springs, ¾ mile apart; irrigation and industrial.
53	4 miles northwest of Crane, sec. 34, T. 24 S., R. 33 E.	Crane Hot Spring	Valley alluvium near faulted lava bluffs.	126	180	60, p. 39; 116, p. 41; 118, pp. 39, 57, 64; 174.	1 spring; resort.
54	West side of Middle Fork of Malheur River, Warm Spring Valley, 8 miles northwest of Riverside, sec. 23, T. 22 S., R. 36 E.		Issue from faulted tuffs interbedded with basalt.	138–144	90	118, pp. 41, 81, 83	Several springs; irrigation.
55	West side of South Fork of Malheur River, 8 miles north of Venator, sec. 16, T. 25 S., R. 36 E.		Late Tertiary lava, probably faulted.	104–108	300	118, pp. 41, 81, 83	Do.
56	Near south shore of Silver Lake, sec. 12, T. 26 S., R. 27 E.		Valley alluvium	68	45	118, p. 39	1 spring; irrigation.
57	3½ miles east of Iron Mountain, sec. 33, T. 26 S., R. 28 E.		do	68	5,350	118, p. 39; 174	1 spring; stock water.
58	West side of Harney Lake, 1½ miles west of OO ranch, sec. 34, T. 26 S., R. 28 E.	OO Spring	Base of fault-line bluff of coarse tuff interbedded with Miocene rhyolite.	74	5,500	118, pp. 35, 39, 63; 174.	1 spring; irrigation.
59	OO ranch, sec. 36, T. 26 S.; R. 28 E	OO Barnyard Spring	do	72	1,750	174	Do.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given. [2] Not shown on pl. 8. [3] 48,000–75,000.

Data on thermal springs in the United States—Continued

Oregon—Continued

[See pl. 14]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Harney County—Continued						
60	1 mile southeast of OO ranch, sec. 31, T. 26 S., R. 29 E.	Basque Spring	Base of fault-line bluff of coarse tuff interbedded with Miocene rhyolite.	67–74	1,800	118, pp. 35, 39, 63; 174.	1 spring; irrigation.
61	2 miles southeast of OO ranch, sec. 5, T. 27 S., R. 29 E.	Johnson Spring	do	72	900	118, pp. 35, 39, 63; 174.	Do.
62	3 miles southeast of OO ranch, sec. 8, T. 27 S., R. 29 E.	Hughet Spring	do	68	5,900	118, pp. 35, 40, 57, 63; 174.	Do.
62a	5 miles southeast of OO ranch, secs. 9 and 15, T. 27 S., R. 29 E.	Sizemore Springs	do	66–67	1,600	174	2 springs, ½ mile apart; irrigation.
63	East side of Harney Lake, sec. 8, T. 27 S., R. 30 E.	Lynch Spring	Valley alluvium	65	25	118, pp. 40, 58; 174.	1 spring; not used; sulphur odor.
63a	South side of Mud Lake, sec. 4, T. 27 S., R. 30 E.		do	70	35	174	2 springs, ½ mile apart; stock water.
64	½ mile from southeast shore of Harney Lake, sec. 36, T. 27 S., R. 29½ E.		Miocene lake beds; water issues from soft white sediments at south base of hill of sandstone, associated with lava.	154	180	60, p. 39; 118, pp. 40, 57; 174.	1 spring; not used.
64a	Southeastern part of bed of Harney Lake.		Lake and playa deposits	66–108		174	5 groups of springs disclosed about 1930 by desiccation of lake; not used.
65	West side of valley of Donner and Blitzen River, 5 miles north of P ranch, sec. 13, T. 31 S., R. 32 E.	Hoghouse Spring	Valley alluvium near fault scarp in Miocene basalt.	78–80	1,800	118, p. 40; 174	1 spring; irrigation.
66	1 mile northeast of P ranch, sec. 5, T. 32 S., R. 32½ E.		Valley alluvium	83	100	118, p. 40; 174	1 spring; stock water.
67	1 mile southwest of P ranch, sec. 12, T 32 S., R. 32 E.		Valley alluvium near fault scarp in Miocene basalt.	89	500	118, p. 40; 174	1 spring; irrigation.
68	West border of Alvord Desert, 6 miles south of Alvord ranch, sec. 33, T. 34 S., R. 34 E.		Issue near base of early Tertiary lava in fault zone along east side of Steens Mountain.	168–177	135	118, pp. 37, 40, 73; 169, p. 215.	Several springs; local use.
69	2 miles south of Alvord Lake, sec. 15, T. 37 S., R. 33 E.		Pleistocene lake deposits near fault zone.	([9])		118, pp. 37, 40	Several springs; not used.
70	Old borax works, 2½ miles south of Alvord Lake; sec. 15, T. 37 S., R. 33 E.		Pleistocene lake deposits	97	900	118, pp. 37, 40, 73	1 spring; formerly supply to borax works; not used.

71	5 miles northeast of Flagstaff Butte, sec. 24, T. 38 S., R. 37 E.		Tuffs interbedded with Miocene lava.	96–100	30	118, pp. 41, 79; 174	4 springs; stock water.
71a	5 miles southwest of Whitehorse Ranch		do	114	10	174	Bathing.
72	North side of Trout Creek, ½ mile below mouth of Little Trout Creek, sec. 16, T. 39 S., R. 37 E.		do	128	45	118, pp. 40, 73, 81	Several springs; stock water.
	Malheur County						
73	Near Willow Creek, 20 miles northwest of Vale, sec. 4, T. 16 S., R. 43 E.		Tertiary lake beds (Payette formation) near Columbia River basalt.	Hot		63, p. 35	1 spring; local use. Drilled well also has hot water.
74	Valley of Warm Creek near Beulah, about sec. 11, T. 19 S., R. 37 E.		Tertiary lake beds (Payette formation), in region of late Tertiary lava.	185	Small	60, p. 29	Several springs; local use.
75	12 miles northwest of Vale, sec. 9, T. 18 S., R. 43 E.	Neal Hot Spring	Tertiary lake beds (Payette formation); probably faulted.	168	24	60, p. 28; 63, p. 34	Local use.
76	Malheur River 15 miles southwest of Vale, about sec. 18, T. 19 N., R. 43 E.		Tertiary lake beds (Payette formation) near late Tertiary lava.	Hot		63, p. 33	Several springs; not used.
77	South side of Malheur River ½ mile east of Vale, sec. 20, T. 18 S., R. 45 E.	Vale Hot Springs	Tertiary lake beds (Payette formation).	198	20	60, p. 28; 174	1 spring; bathing resort; 140-foot well also has hot water.
78	Malheur River, 3 miles west of Ontario, sec. 31, T. 17 S., R. 47 E.		do	164		143, p. 325; 169, p. 215.	1 spring; local use.
79	Owyhee River, sec. 12, T. 21 S., R. 45 E.	Mitchell Butte Hot Springs.	Issue from crevices in nearly horizontal strata of massive conglomerate of Payette formation.	122–141		63, p. 33; 174	3 main springs; local use.
80	Owyhee River, about sec. 14, T. 21 S., R. 45 E.	Deer Butte Hot Spring	Late Tertiary tuff and lava	115		60, p. 28; 63, p. 33; 174.	Local use.
81	Owyhee River near Sniveley's ranch, about sec. 25, T. 21 S., R. 45 E.	North Black Willow Spring.	Issues from tuffaceous shale of Payette formation (Tertiary) at intersection of 2 faults.	67		174	Do.
82	Owyhee River, about sec. 35, T. 21 S., R. 45 E.	South Black Willow Spring.	Issues near fault in late Tertiary lava.	71		63, p. 34; 174	Do.
83	Owyhee River, 2 miles below mouth of Dry Creek, about sec. 10, T. 23 S., R. 44 E.		Alluvium overlying late Tertiary lava.	Hot		63, p. 33; 174	Several springs; not used.
84	Near South Fork of Malheur River, 5 miles south of Riverside, sec. 20, T. 24 S., R. 37 E.		Late Tertiary lava, probably faulted.	106–143	60	118, p. 83	Several springs; irrigation.
84a	30 miles northwest of Jordan Valley, sec. 18, T. 27 S., R. 43 E., on Owyhee River.	(2)	do	Hot	Large	174	Unused.
84b	25 miles northwest of Rome, at north end of Saddle Mountain.	(2)	do	Warm	Small	174	Do.
85	One-half mile west of Jordan Valley, sec. 2, T. 30 S., R. 46 E.	Canter's Hot Springs	Early Tertiary lava	120	10	169, p. 215; 174	3 main springs; bathing.

1 Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given. 2 Not shown on pl. 8. 9 Near boiling.

Data on thermal springs in the United States—Continued

Oregon—Continued

[See pl. 14]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Malheur County—Continued						
85a	6 miles southwest of Rome	Scott's Springs [2]	Basaltic lava	68	5,000	174	Several springs; irrigation.
85b	24 miles southwest of Rome	Tudor's Springs [2]	do	68	6,000	174	Do.
85c	40 miles south of Jordan Valley	(2)	Rhyolite beneath basalt	88–95	1,000	174	About 15 springs for ½ mile along south fork of Owyhee River; unused.
86	6 miles north of McDermitt, Nev., about sec. 36, T. 40 S., R. 42 E.		Issue near fault in Tertiary lava.	130	200	169, p. 215; 174	Several springs; irrigation.

Pennsylvania

[See pl. 8]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Perry County						
1	Near Sherman Dale, 15 miles northwest of Harrisburg.	Perry County Warm Spring.	Folded Paleozoic rocks	72	90	163, p. 174; 166, p. 150; 169, p. 45; 170, p. 74; 174.	Formerly hotel; water bottled. Only local use in 1934.

South Dakota

[See pl. 8]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Fall River County						
1	Hot Springs, in west part of town	Hot Springs	Source of water is Deadwood sandstone (Cambrian) at depth of 1,000 feet. Issues from Minnekahta limestone (Permian or Triassic).	98	200	120, p. 575; 122, pp. 28, 54; 170, p. 77; 171, pp. 428*, 431; 173, pp. 591*, 739.	8 springs; resort, sanitarium, U. S. Army hospital.
2	3 miles west of Hot Springs	Hot Brook	do	90	50	120, p. 575	Irrigation.
3	10 miles southwest of Hot Springs	Cascade Springs	do	90	100	170, p. 77; 121, p. 9*; 122, pp. 28, 54.	Several springs; irrigation. Supply Cascade Creek.

Texas

[See pl. 8]

	Hudspeth County						
1	Near bank of Rio Grande, at south end of Quitman Mountain.		Lower Cretaceous sandstone and shale (Trinity group); probably faulted.	100		169, p. 125; 174	1 spring, near river bank; local use.
2	Near bank of Rio Grande, 2 miles east of south end of Quitman Mountain.		do	118		169, p. 125; 174	Pool on river flat; bathing; overflow ceased after earthquake in 1932.
	Presidio County						
3	Hot Spring Creek, 5 miles east of Rio Grande and 7 miles northeast of Ruidosa.		Quaternary alluvium over Cretaceous rocks; probably faulted.	114	45	143, p. 324; 166, p. 153; 174.	1 spring; bathing.

Utah

[See pl. 13]

	Box Elder County						
1	18 miles north of Terrace railroad station, sec. 20, T. 12 N., R. 15 W.		Valley alluvium, probably artesian structure.	Warm	900	128, p. 66	1 spring; irrigation.
2	18 miles southeast of Snowville, T 13 N., R. 5 W.	Blue Springs	Valley alluvium near Carboniferous rocks.	86		128, pl. 1; 169, p. 185.	6 springs; not used.
3	Near Malad River, 2 miles southwest of Plymouth.	Udy's Hot Springs	Near Wasatch fault in Paleozoic rocks.	90–122	3,500	128, p. 42; 169, p. 186; 174.	8 main springs; resort, bathing; saline water.
4	12 miles north of Brigham City, T. 11 N., R. 2 W.	Crystal Springs	On Wasatch fault at base of slopes of Paleozoic rocks.	121–128		128, p. 42*; 163, p. 337; 166, p. 151; 169, p. 185; 171, p. 462.	About 30 springs; local use.
5	East side of Promontory Point, T. 6 N., R. 5 W.		Pre-Cambrian schist and gneiss; probably minor fault.	84		169, p. 186	1 spring; not used.
	Weber County						
6	8 miles northwest of Ogden, T. 7 N., R. 2 W.	Utah Hot Springs	Fault in Cambrian quartzite, parallel to Wasatch fault.	131–144	110	130, pp. 26, 27*; 166, p. 151; 167, p. 30; 169, pp. 186, 187*; 171, p. 461*; 173, pp. 620–621*.	12 springs; resort. Also called Bear River Hot Springs. Saline and iron-bearing water. Several springs situated across county line in Box Elder County.
6a	9¾ miles north of Ogden	Clay's Hot Springs	Base of quartzite ridge, on Wasatch fault.	140	50	174	2 springs; medical bathing. Saline, iron-bearing water.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

[2] Not shown on pl. 8.

Data on thermal springs in the United States—Continued

Utah—Continued

[See pl. 13]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References[1]	Remarks
	Weber County—Continued						
7	12 miles northeast of Ogden	Patio Spring	Quaternary lake beds	68	200	174	Bathing.
8	Mouth of Ogden Canyon on east border of Ogden, T. 6 N., R. 1 W.	Ogden Hot Springs	Syenite along Wasatch fault	121, 150		84, p. 401; 130, pp. 25, 27*; 166, p. 151; 169, p. 186.	2 springs; bathhouse and pool.
	Tooele County						
9	West side of Stansbury Range, T. 2 S., R. 8 W.	Big Springs	Near fault in Paleozoic rocks	74		169, p. 186; 174	2 springs; brackish, not used.
10	5 miles northwest of Grantsville	Grantsville Warm Springs	Lake sediments, south edge of mud flat bordering Great Salt Lake.	74–91	50	128, pl. 1; 166, p. 151; 169, p. 186; 174.	6 springs; municipal bath house and pool; water brackish. Deposit calcareous tufa.
10a	4 miles southwest of Stockton	Morgan's Warm Springs	Lake-bed sediments; at base of gravel knoll in valley.	80	500	174	1 spring, ponded; bathing, irrigation.
10b	4½ miles southwest of Stockton	Russell's Warm Springs	Lake-bed sediments; in valley.	90	200	174	1 spring, ponded; irrigation.
	Salt Lake County						
11	4 miles north of Salt Lake City	Beck's Hot Springs	On Wasatch fault at base of slopes of Paleozoic rocks.	128		84, p. 438*; 131, pp. 409–418; 163, p. 336; 169, p. 185; 171, p. 458*; 173, p. 617*.	Several springs; resort; sulphur odor.
12	Northwest part of Salt Lake City	Wasatch Springs	Unconsolidated deposits at base of mountain spur of Carboniferous limestone at foot of mountains; near Wasatch fault.	112	1,000	124, p. 44; 169, pp. 186, 187*; 171, p. 463*; 173, pp. 619, 620*.	Resort, sanitarium, munici pal baths. Also supplies Crystal Springs. Baths nearby.
13	4 miles southwest of Draper, T. 4 S., R. 1 W.	Crystal Springs	Valley alluvium	70		124, p. 48; 166, p. 151; 169, p. 186.	Several springs; bathing.

	Wasatch County						
14	4½ miles northwest of Heber	Schneitter's Hot Pots	Beds of Wasatch formation (Eocene); Carboniferous limestone nearby.	85–116	20	39, p. 47; 84, p. 317; 166, p. 256; 169, p. 186; 171, p. 459*; 173, pp. 617–618*.	20 springs; local resort; bathing. Area of tufa 2 miles in extent.
14a	4 miles northwest of Heber	Luke's Hot Pots [2]	do	78–110	30	174	Local resort; bathing.
14b	3½ miles northwest of Heber	Buhler's Springs [2]	do	80–100	10	174	Bathing.
	Utah County						
15	Northwest shore of Utah Lake		Lake deposits; water issues on shore and in lake.	Warm	200	124, p. 49; 174	Several springs; not used.
16	South shore of Utah Lake, 8 miles northwest of Payson, T. 8 S., R. 1 E.		Valley alluvium	88	200	124, p. 55	1 spring; local use.
17	North end of Long Ridge, 2 miles east of Goshen, T. 10 S., R. 1 E.		Talus slope near faulted Paleozoic rocks.	70	2,000	124, p. 55	Several springs; local use. Source of warm creek.
18	Spanish Fork Canyon, 15 miles south of Provo, T. 9 S., R. 3 E.	Castilla Mineral Springs	Near Wasatch fault in Carboniferous rocks.	111, 145		38, p. 47; 166, p. 257; 169, p. 185.	3 springs; resort.
19	Diamond Creek, 15 miles east of Springville, SE¼ sec. 14, T. 8 S., R. 5 E., Uinta National Forest.		Eocene lake deposits; probably artesian structure.	Warm	700	174	2 springs; not used; sulphur odor.
	Uintah County						
19a	Canyon of Green River, 12 miles northeast of Jensen.	(?)	Mesozoic or Paleozoic rocks	90	10	174	2 springs at river's edge; not used.
	Juab County						
20	North end of Fish Spring Mountains, T. 11 S., R. 14 W.	Hot Springs	Valley alluvium along Quaternary fault in Paleozoic rocks overlain by Tertiary lava.	74–78		127, p. 125; 129, p. 534; 166, p. 151; 169, p. 185.	Several springs; local use. Called Fish Springs in early reports.
21	¾ mile south of Hot Springs	Big Spring	Near faulted Paleozoic rocks	85		127, p. 125; 129, p. 534; 169, p. 186.	3 springs; not used.
22	1½ miles south of Hot Springs, T. 11 S., R. 14 W.	Fish Springs	do	81		127, p. 125; 129, p. 534; 169, p. 186.	2 springs; local use.
23	Miller's ranch, 8 miles south of Trout Creek, about sec. 33, T. 14 S., R. 18 W.		Valley alluvium; probably artesian structure.	64	500	127, p. 131	Several springs rise in pools; irrigation.
24	Sevier Desert, 30 miles north of Deseret, T. 14 S., R. 8 W.		Fractured Tertiary lava	110–178	300	123, p. 333; 127, pp. 43, 103; 169, p. 185.	About 20 springs; not used.
	Millard County						
25	Snake Valley, 1 mile west of Gandy post office, sec. 31, T. 15 S., R. 19 W.		Issue from crevices in Paleozoic limestone.	82	Large	127, pp. 42, 131; 169, p. 185.	Several springs; irrigation; tufa deposits.
26	Snake Valley, 2 miles south of Foote's ranch, sec. 9, T. 16 S., R. 18 W.		Valley alluvium; probably artesian structure.	68	1,000	127, p. 131; 169, p. 186.	Several springs rise in pools; irrigation.
27	Snake Valley, 12 miles southeast of Smithville, sec. 11, T. 18 S., R. 18 W.	Knoll Springs	Valley alluvium near Carboniferous rocks.	68–71		127, p. 130; 169, p. 186.	Several springs; local use; sulphur odor.
28	3 miles northwest of Hatton, NE¼ sec. 24, T. 22 S., R. 6 W.		Issue from tuffaceous beds in Tertiary lava.	94	Large	127, pp. 43, 90	1 spring; irrigation.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

[2] Not shown on pl. 8.

Data on thermal springs in the United States—Continued

Utah—Continued

[See pl. 13]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Sanpete County						
29	1 mile northwest of Wales, secs. 13 and 24, T. 15 S., R. 2 E.	Brewer's Springs	Valley alluvium near fault in Eocene lake beds.	57-62	400	125, p. 59	3 springs; domestic; irrigation.
30	3 miles south of Manti, sec. 23, T. 18 S., R. 2 E.		Issue from sandstone near fault in Eocene lake beds.	59, 62	40	125, p. 59	Lowry Spring in NE¼ sec. 23; Squires Spring in SE¼ sec. 23; irrigation.
31	1 mile south of Manti, SW¼ sec. 13, T. 18 S., R. 2 E.	Livingston Warm Springs	Probably along fault in Cretaceous and Tertiary beds.	62, 73	285	125, p. 59	2 springs; domestic, irrigation.
32	2 miles southeast of Manti, NW¼ sec. 17, T. 18 S., R. 3 E.	Manti Springs	Lake beds of Wasatch formation (Eocene).	59, 65	30	125, p. 59	Do.
33	2 miles northeast of Sterling, SE¼ sec. 35, T. 18 S., R. 2 E.	Morrison Spring	Lake beds of Wasatch formation (Eocene).	61	2,500	125, p. 59	Irrigation.
34	Gunnison, SE¼ sec. 18, T. 19 S., R. 1 E	Gunnison Spring	Valley alluvium	61	8	125, p. 58	Stock water.
35	½ mile south of Sterling, SE¼ sec. 4, T. 19 S., R. 2 E.	Ninemile Warm Spring	Valley alluvium near faulted lake beds of Wasatch formation (Eocene).	72	900	125, p. 59	Domestic; irrigation.
36	8 miles northeast of Redmond, SE¼ sec. 32, T. 20 S., R. 2 E.		Faulted lake beds of Wasatch formation (Eocene).	58	15	125, p. 58	1 spring; irrigation.
	Sevier County						
37	Near Redmond, secs. 11 and 12, T. 21 S., R. 1 W.	Redmond Springs	do	70	6,000	125, p. 58	Several springs; domestic; irrigation.
38	2 miles northeast of Salina, SW¼ sec. 17, T. 21 S., R. 1 E.	Salt Spring	Along fault at base of hills of Jurassic rocks.	72	2	125, p. 58	Not used.
39	2 miles west of Aurora, sec. 1, T. 22 S., R. 2 W.		Faulted Eocene lava	60	20	125, p. 58	Oak Spring in NE¼ sec. 1; Christianson Spring in SW¼ sec. 1; stock water.
40	1 mile north of Glenwood, NW¼ sec. 23, T. 23 S., R. 2 W.	Herrin's Hole Spring	At base of ridge of faulted Eocene lava.	63	450	125, p. 58	Irrigation.
41	1 mile west of Glenwood, SW¼ sec. 27, T. 23 S., R. 2 W.	Cove Springs	At northeast end of ridge of faulted Eocene lava.	60	4,000	125, p. 58	Several springs; irrigation.
42	Richfield, NE¼ sec. 26, T. 23 S., R. 3 W	Richfield Hot Springs	Joints along fault in Eocene limestone.	74	1,500	125, pp. 25, 39	Several springs; town waterworks; irrigation.

43	Near Glenwood, sec. 25, T. 23 S., R. 2 W.		At base of ridge of faulted Eocene lava.	60	130	125, p. 58	Domestic; irrigation. Indian Spring in NW¼ sec. 25; Parcel Creek Spring in SW¼ sec. 25.
44	2 miles southeast of Richfield, sec. 5, T. 24 S., R. 2 W.		At base of ridge of igneous rock.	52-61	4,500	125, p. 58	Several springs; irrigation.
45	6 miles south of Richfield, NW¼ sec. 25, T. 24 S., R. 3 W.		Eocene sediments at base of foothills.	59	25	125, p. 58	1 spring; domestic; irrigation
46	2 miles northeast of Joseph, SW¼ sec. 6, T. 25 S., R. 3 W.	Jericho Spring	Valley alluvium	65	700	125, p. 58	Irrigation.
47	2 miles southeast of Monroe, NE¼ sec. 27, T. 25 S., R. 3 W.	Johnson Spring	Eocene lava and tuff, along fault.	80	200	125, p. 58	Do.
48	½ mile east of Monroe, sec. 15, T. 25 S., R. 3 W.	Cooper Hot Springs	From tuff at base of mountains of Tertiary igneous rocks; fault at base of Sevier Plateau.	144–156	100	125, pp. 36*, 58	Several springs; irrigation.
49	1 mile southeast of Joseph, NE¼ sec. 23, T. 25 S., R. 4 W.	Joseph Hot Springs	Issue through calcareous tufa at base of low ridge of Tertiary lava.	135–146	30	125, pp. 25, 35, 58	Do.
50	Sevier, NE¼ sec. 32, T. 25 S., R. 4 W	Sevier Spring	Valley alluvium	59	100	125, p. 58	Domestic; stock water.
	Beaver County						
51	West slope of Mineral Mountains, 15 miles northeast of Milford.	Roosevelt Hot Spring	At base of granitic mountains	192	3	126, pp. 20, 50*	Formerly bathing; stock water. Deposits tufa and sinter.
52	3 miles south of Thermo railroad siding, 16 miles west of Minersville, T. 30 S., R. 12 W.		Valley alluvium near Tertiary lava; probably faulted.	90–175	20	126, pp. 21, 50*	About 16 small springs, for a half mile along low ridge; ledges of dense calcareous tufa; stock water.
53	1 mile east of Minersville, in bank of Beaver River, sec. 7, T. 30 S., R. 9 W.	Radium Warm Springs	From river gravel, near quartzite ledges.	97	57	126, pp. 21, 45*; 174	3 springs; bathing, irrigation. Formerly Dotson's Spring.
	Washington County						
54	Rio Virgin, 2 miles north of Hurricane	La Verkin Hot Springs	On fault in Triassic and Carboniferous rocks.	108–132	1,000	169, p. 186; 171, p. 462; 174.	Several springs; resort, bathing.
	Garfield County						
55	25 miles southwest of Panguitch, about T. 37 S., R. 7 W.		Wasatch formation (Eocene) overlain by Tertiary lava.	Warm		166, pp. 151, 154	1 main spring; not used.
	Emery County						
56	Labyrinth Canyon of Green River, about T. 25 S., R. 17 E.	Undine Springs	Triassic sandstone	do		166, pp. 151, 155	Many small springs; not used; tufa deposit.
	San Juan County						
57	Warm Spring Canyon near its junction with "Narrow Canyon" or "Dark Canyon" of Colorado River.		do	91		166, pp. 151, 155	1 main spring; not used.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

Data on thermal springs in the United States—Continued

Virginia [10]

[See pl. 9]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Page County						
1	Near Compton	Limestone Springs		61–66		132, p. 584; 133, p. 7; 166, p. 150.	3 or more springs, on different properties; local use.
	Rockingham County						
2	1 mile south of Bridgewater	Warm Spring		64	500	133, p. 46	Local use.
	Augusta County						
3	1 mile southeast of Burketown	Dice's Spring		65	1,500–2,000	133, p. 47	Do.
4	Middle River Bridge, 2¼ miles west of Fort Defiance.	Fitzgerald Spring		61	60	133, p. 47	Do.
	Highland County						
5	2¼ miles northeast of Bolar	Bragg Spring		75	50	133, p. 41	Do.
6	3 miles northeast of Bolar	Bolar Spring		72	1,500	133, p. 41	Do.
	Bath County						
7	Warm Springs	Warm Sulphur Springs		91–96	1,200	56, p. 373*; 132, pp. 557*, 580; 133, p. 42; 169, pp. 57, 68*; 171, p. 494*.	4 springs; resort.
8	Hot Springs	Hot Springs		72–106		56, p. 373*; 132, pp. 555*, 580; 133, p. 43; 169, pp. 56, 61*; 171, p. 490*; 173, pp. 657–659*, 745.	8 springs; 7 warm springs, 1 cool; resort.
9	Healing Springs	Healing Springs		82–88		56, p. 373*; 132, p. 581; 133, p. 143; 167, p. 33*; 169, pp. 56, 60*; 171, p. 493*; 173, p. 660*.	4 springs; resort; bottled. Formerly Sweet Alum Springs.

	Rockbridge County						
10	Panther Gap, 1½ miles west of Goshen	Mill Mountain Springs		60–66	900	132, p. 583; 133, p. 49.	3 springs: 60°, 50 gallons a minute; 65°, 800 gallons a minute; 66°, 50 gallons a minute; local use.
11	Rockbridge Baths	Rockbridge Baths		72		132, p. 584; 133, p. 49; 169, p. 57; 173, pp. 651, 652*.	3 springs; resort. Formerly Strickler's Spring.
	Alleghany County						
12	Jackson River, 2 miles south of Falling Spring.	Layton Springs		63, 72	200	132, p. 583; 133, p. 44.	2 springs, 1 on each bank of river; local use. Formerly Keyser's Springs.
13	8 miles southwest of Healing Springs	Falling Spring		74	7,000	132, p. 581; 133, p. 44.	Local use.
14	3 miles north of Sweet Chalybeate	Sweet Chalybeate Springs		63–68	280	132, pp. 553*, 581; 133, p. 45; 169, pp. 57, 67*; 171, p. 509*.	3 springs; resort.
15	Near Sweet Chalybeate					133, p. 45	4 springs, local use, as follows: Lee Carter Spring, 1½ miles northeast of Sweet Chalybeate, 63°, 20 gallons a minute; C. B. Hunter Spring, ½ mile north of Sweet Chalybeate, 60°, 10 gallons a minute; R. O. Stone Spring, at Sweet Chalybeate, 73°, 100 gallons a minute; Sweet Chalybeate Spring at Sweet Chalybeate, 76°, 1,000 gallons a minute.
	Botetourt County						
16	Mill Creek, 3¼ miles east of Gala	Lithia Spring		65	300	132, pp. 563*, 581; 133, p. 51.	Local use. Formerly Wilson Thermal Spring.
	Bedford County						
17	Buford's Gap	Blueridge Springs		66–75		132, p. 584; 166, p. 150.	3 springs; local use. Formerly Buford's Gap Springs.
	Giles County						
18	Eggleston	New River White Sulphur Springs.		85	3	132, p. 584; 169, p. 56.	3 springs; resort.
	Pulaski County						
19	Sassin, 8½ miles north of Pulaski	Hunter's Pulaski Alum Springs.		72		171, p. 496*	2 springs; resort.
	Washington County						
20	Near North Fork of Holston River	McHenry's Spring		68		132, p. 562*, 581; 169, pp. 56, 60*.	Local use.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

[10] All the thermal springs in Virginia and West Virginia issue from Paleozoic sedimentary rocks, folded and faulted; usually on anticlinal axes with steeply dipping beds of Cambrian and Ordovician limestone.

Data on thermal springs in the United States—Continued

Washington

[See pl. 14]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Whatcom County						
1	East side of Mount Baker, NE¼ sec. 30, T. 38 N., R. 9 E., Mount Baker National Forest.	Baker Hot Spring	Granite overlain by late Tertiary lava.	108	7	174	Not used.
	Clallam County						
2	14 miles by road southwest of Crescent Lake, NW¼ sec. 32, T. 29 N., R. 9 W., Olympic National Forest.	Sol Duc Hot Springs	Pre-Tertiary metamorphic rocks.	132	50	174	3 main springs in group covering 1 acre, 8 others in river bed; resort.
3	11½ miles by trail southwest of Elwha post office, SW¼ sec. 27, T. 29 N., R. 8 W., Olympic National Forest.	Olympic Hot Springs	do	120–125	135	174	17 springs covering 5 acres; resort.
	Snohomish County						
4	1 mile north of Sulphur Creek Shelter, NE¼ sec. 30, T. 32 N., R. 12 E., Mount Baker National Forest.	Sulphur Creek Spring	Granite	98	4	174	Not used.
5	Near White Chuck River, sec. 1, T. 30 N., R. 12 E., Snoqualmie National Forest.	White Chuck Hot Springs	do	100–110	30	174	4 springs; bathing. Deposit of iron-stained tufa.
6	North Fork of Skykomish River, 5 miles east of Galena, about sec. 25, T. 28 N., R. 11 E.	San Juan Hot Springs	do	100	25	135, p. 38; 174	3 springs; not used.
	King County						
7	5 miles west of Scenic, sec. 28, T. 26 N., R. 13 E.	Scenic Hot Springs	do	122	30	135, p. 38; 137, pp. 26*, 79–81.	Several springs; resort; sulphur water. Water piped 2 miles to hotel. Formerly Great Northern Hot Springs.
8	66 miles east of Seattle, sec. 15, T. 23 N., R. 11 E., Snoqualmie National Forest.	McDaniels Hot Springs	do	114–127	30	174	4 springs; resort.

9	Hot Springs railroad station, sec. 21, T. 20 N., R. 9 E.	Hot Springs	Tertiary basalt	120-122		135, pp. 37-38*	5 springs; resort.
	Kittitas County						
10	8 miles east of Ellensburg, sec. 5, T. 17 N., R. 20 E.	Clerf Spring	Issues from crevices in basalt overlying shale and sandstone of Ellensburg formation (Miocene); probably artesian structure.	68	1, 100	134, p. 45; 136, p. 7; 138, p. 56.	Irrigation; original flow increased fourfold by excavating.
	Lewis County						
11	Near south base of Mount Rainier, NE¼ sec. 4, T. 14 N., R. 10 E., Rainier National Forest.	Ohanapecosh Hot Springs	Tertiary basalt	109-120	60	174	5 springs; resort, sanitarium.
	Yakima County						
12	North Fork of Simcoe Creek, sec. 9, T. 11 N., R. 15 E., Yakima Indian Reservation.		do	90	40	137, pp. 65, 79-81	Several springs; bathing.
13	10 miles north of Sunnyside, sec. 15, T. 11 N., R. 23 E.	Nicolai Spring	Ellensburg formation (Miocene shale and sandstone); probably artesian structure.	66	300	139, pp. 29, 46	Irrigation.
	Klickitat County						
14	5 miles southeast of Glenwood, about sec. 16, T. 6 N., R. 13 E.		Tertiary basalt	76	Large	137, pp. 31, 79-81	Several springs; irrigation. Gas rises with the water.
15	8 miles west of Goldendale, sec. 12, T. 4 N., R. 14 E.	Blockhouse Mineral Springs.	do	67	50	137, pp. 31*, 79-81; 173, p. 666*; 174.	2 springs; resort.
	Skamania County						
16	Near Cascade, sec. 16, T. 2 N., R. 7 E.	Cascade Warm Springs	do	96	20	137, pp. 44, 79-81; 171, p. 515; 173, pp. 668-669*.	4 springs; resort; also called Moffet's Hot Springs.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.

Data on thermal springs in the United States—Continued

West Virginia [10]

[See pl. 9]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Morgan County						
1	Berkeley Springs	Berkeley Springs	Oriskany sandstone steeply inclined, at contact with overlying Marcellus shale.	73–75	2,000	132, p. 581; 133, p. 7; 140, p. 60*; 169, pp. 69, 71*; 171, p. 520*; 173, pp. 670–672*.	5 springs; resort. Property owned and administered by the State. One of the oldest resorts in the United States.
	Hampshire County						
2	Capon Springs	Capon Springs	Northwest side of anticline of Paddy Mountain, nearly vertical strata.	54–66	200	132, p. 583; 133, p. 7; 169, pp. 69, 71*; 171, p. 523*; 173, pp. 673–674*, 749.	4 springs; resort.
	Pocahontas County						
3	½ mile southeast of Dunmore	Pritchard Spring		63	1,000–1,500	133, p. 37	Local use.
4	Huntersville	Curry Spring	On anticline of Brown Mountain.	64	400	132, p. 584; 133, p. 37.	Local use. Formerly Nap's Creek Spring.
5	Minnehaha Springs	Minnehaha Springs		68½	400–800	133, p. 37	Local use.
	Greenbrier County						
6	3 miles north of White Sulphur Springs	Reed Spring (northern)		62½	800	133, p. 38	Do.
7	2 miles north of White Sulphur Springs	Reed Spring (southern)		62½	800	133, p. 38	Do.
8	White Sulphur Springs	White Sulphur Springs	On anticlinal axis	61, 64	30	132, pp. 550*, 581; 133, p. 38; 169, pp. 69, 72*; 171, p. 525*; 173, pp. 682–685*, 755.	2 springs; resort.
	Monroe County						
9	2 miles northeast of Sweet Springs	Buttermilk Spring		71	10	133, p. 39	Local use.
10	Sweet Springs	Old Sweet Spring		73	400	132, pp. 552*, 769; 133, p. 39; 169, pp. 70, 73*; 171, p. 528*; 173, pp. 676, 677*.	Resort.

Wyoming
[See pls. 11, 12]

1-96	Yellowstone National Park. (See p. 66.)					141, pp. 122-178; 143, pp. 65-303; 144; 145; 147; 148; 155; 156; 157; 161; 162a.	Hotel resorts at Mammoth Springs and in Lower and Upper Geyser Basins.
	Park County						
97	4 miles southwest of Cody	Demaris Hot Springs	Issue from Permian limestone underlying the Chugwater red beds; water probably rises from Tensleep or Deadwood formation; anticlinal axis.	76-100		57, pp. 27, 55; 146, p. 67; 151, p. 314; 152, p. 61; 153, p. 451; 162, p. 11*; 169, p. 183; 173, pp. 701, 702*.	Several springs; resort; sanitarium. Sulphur deposits and extinct hot springs. Also called Cody Hot Springs.
	Big Horn County						
98	Sheep Canyon of Big Horn River near mouth of Five Springs Creek, T. 55 N., R. 94 W.	(2)	Folded Triassic and Carboniferous rocks.	Warm		152, p. 62	Several springs; local use.
99	Near upper end of Black Canyon of Big Horn River, T. 53 N., R. 94 W.		Closely folded Triassic and Carboniferous rocks.	do	Small	152, p. 61	1 spring; not used.
	Teton County						
100	Near Snake River, 2 miles south of Yellowstone National Park boundary, Teton National Forest, sec. 8, T. 48 N., R. 115 W.	(2)	Lava overlying Cretaceous shale	Hot	100	174	Do.
101	Snake River, 4 miles below mouth of Hoback River, T. 39 N., R. 116 W.		Triassic red beds, near fault	94	100	65, p. 31; 162, p. 14; 169, p. 183.	Several springs; bathing, irrigation; sulphur odor.
102	Gros Ventre Mountains, NE¼ sec. 6, T. 39 N., R. 113 W., Teton National Forest.	Granite Hot Springs	Sandstone of Wasatch formation (Eocene) near granite.	110	360	174	2 springs; not used.
	Lincoln County						
103	West side of Salt River, 3 miles north of Auburn.		Limestone, probably Jurassic or Triassic.	122	20	169, p. 183	Several springs; bathing; also ½ mile farther south is another group, about 114°, 2 gallons a minute.
	Sublette County						
104	Green River near Wells, SW¼ sec 2, T. 38 N., R. 110 W., Wyoming National Forest.		Carboniferous limestone	Warm	Large	174	6 springs; not used.
105	Near Fremont Butte, T. 32 N., R. 107 W.		Granite	Hot	Small	162, p. 14	1 spring; bathing.

[1] Numbers correspond to numbers of the bibliography; asterisk indicates that analyses of the water are given.
[2] Not shown on pl. 8.
[10] All the thermal springs in Virginia and West Virginia issue from Paleozoic sedimentary rocks, folded and faulted; usually on anticlinal axes with steeply dipping beds of Cambrian and Ordovician limestone.

Data on thermal springs in the United States—Continued

Wyoming—Continued

[See pls. 11, 12]

Map no.	Location	Name	Geology	Temperature (° F.)	Approximate discharge (gallons a minute)	References [1]	Remarks
	Fremont County						
106	Wind River below Warm Spring Creek, 4 miles northwest of Dubois.		Tertiary beds overlying Carboniferous rock.	84		142, p. 267; 169, p. 184.	Several springs and tufa deposits of extinct springs; local use.
107	Near mouth of Little Warm Spring Creek, 3 miles southwest of Dubois.		Carboniferous beds near granite area.	68		142, p. 268; 169, p. 184.	Several springs; tufa deposit; local use.
108	Near Fort Washakie, in valley of Little Wind River, NE¼ sec. 2, T. 1 S., R. 1 W., Shoshone Indian Reservation.	Fort Washakie Hot Springs.	Quaternary deposits over Triassic red beds, near axis of Fox Hills anticline.	110	2,000	57, pp. 16, 55, 86; 162, p. 10*; 169, p. 183; 173, p. 703*.	Several springs in deep pools; resort.
109	4 miles southwest of Hailey, T. 30 N., R. 97 W.		Chugwater red beds (Triassic).	96	100	158, p. 236; 162, p. 14; 169, p. 183.	1 main spring; irrigation; sulphur odor.
110	Near Sweetwater River, 12 miles southwest of Myersville, near center of T. 29 N., R. 96 W.		Tertiary sandstone (Oligocene?).	Warm		156, p. 236	Several springs; local use.
	Hot Springs County						
111	Big Horn River at Thermopolis	Big Horn Hot Springs	Issue from Chugwater red beds (Triassic) near faulted axis of anticline.	135	10,000	149, pp. 194–200*; 150, pp. 39, 40; 151, pp. 314, 315*; 152, p. 62*; 154, p. 376; 159, p. 136; 160, p. 61; 162, p. 5; 169, p. 183; 173, pp. 699–701*.	1 large and several small springs; resort; State reserve; park, bathhouse, and pool; large deposits of tufa. Also known as Thermopolis Hot Springs.
	Natrona County						
112	Horse Creek, 15 miles north of Independence, sec. 35, T. 32 N., R. 86 W.		Tertiary beds near exposure of Chugwater red beds (Triassic).	Warm	Large	158, p. 236; 169, p. 184.	Several springs; local use.
113	Fremont Canyon of North Platte River, 1 mile above Alcova, T. 30 N., R. 83 W.	Alcova Hot Springs	Faulted area of folded Cretaceous and Triassic rocks.	139	75	158, p. 236; 162, pp. 8, 9*; 169, p. 183.	Several springs; resort.

	Converse County						
114	9 miles south of Douglas, T. 31 N., R. 71 W.		Folded Cretaceous and Triassic rocks.	Warm		162, p. 15	1 spring; bathing, irrigation.
	Carbon County						
115	Saratoga	Saratoga Springs	Tertiary sandstone	120	10	162, p. 78*; 169, p. 183.	6 springs; resort.
	Albany County						
116	10 miles northwest of Laramie		Cretaceous shale, probably faulted.	74		163, p. 321; 169, p. 184.	1 spring; not used.

[1] Numbers correspond to numbers in bibliography; asterisk indicates that analyses of the water are given.

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UNITED STATES DEPARTMENT OF THE INTERIOR
Harold L. Ickes, Secretary

GEOLOGICAL SURVEY
W. C. Mendenhall, Director

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