PROCEEDINCS OF THE COLORADO SCIENTIFIC SOCIETY.
VOL. VIII, pp. 31-38.

GEOLOGY OF THE HOT SPRINGS OF COLORADO AND SPECULATIONS AS TO THEIR ORIGIN AND HEAT.

BY A. LAKES.

The subject of springs, and especially hot springs, is so germain to the origin of mineral veins that it is one of considerrable interest to the mining man and student of mining geology.

In Colorado we have a vast number and variety of springs, from those icy cold to others of 168 degrees F., and from those of almost chemically pure water to others charged with nearly every known chemical or mineral ingredient to be found in springs.

Nearly all 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. It is a popular notion that hot springs derive their heat directly from a deeply buried volcanic source, such as from lavas once poured out on the surface and cooled, but still retaining their heat at considerable depths. Undoubtedly this is true in regions of very recent or present volcanic activity, such as the geysers and hot springs of Iceland, but we doubt if the heat of Colorado hot springs can be attributed to any such direct volcanic source, but rather to the great depths of the fissures in fault planes caused by mountain movements, irrespective of any immediate or great exhibition of volcanic activity.

We know that in regions of active volcanoes a high internal temperature is still found in springs of hot water in what is known as the solfataric period or decline of a volcanic eruption, and that these hot springs may continue for centuries to maintain their heat.

The neighborhood of large masses of lava or of recent volcanic activity may raise the subterranean temperature much above its normal condition and this may not disappear for many thousand years after the volcanic activity has wholly ceased. The cooling down of so notoriously bad a heat conductor as a subterranean mass of lava is a very slow process. But can we think that lavas like those of the Table Mountain, at Golden, and the dikes at Rallston and Valmont, which were erupted so long ago as in late Cretaceous or early Tertiary times, if followed down to a great depth would be found now in so heated or semi-molten a condition that water percolating down to and coming in contact with them would be returned to the surface through profound fissures in a boiling state? (We may observe that in our experience springs ascending alongside of volcanic dikes are generally cold), or may we suppose that these dike-filled fissures, at profound depth, are no more molten or eruptive in character than the granite surrounding them.

So many of our Colorado hot springs appear to have so little direct connection with past, or comparatively recent, volcanic activity that we are inclined to look for the source of their heat in the depth to which their fissures may extend, in other words, to the progressive downward increase of heat in the earth.

The influence of seasons upon the earth's temperature descends to a limit. In the tropics it is but a few feet; in Germany at eighty-two feet it is 48·20 degrees; in Siberia, frozen soil is found at 260 feet. Careful observation in various parts of the world give an average increase of temperature, somewhere between one degree for every sixty-four feet, one degree for every 101 feet, one degree for every 110 feet.

Some of our hot springs occur in the immediate vicinity of noted mining camps and would appear like living modern examples, or object lessons, of the methods and forces which made and filled the old fissure veins of the district. The hot soda waters of Idaho Springs is one of these. Hot Springs also occur at Ouray, in the San Juan mining district, not far from the American Nettie and other celebrated mines.

The Chalk Creek hot springs in the Sawatch Range, near Buena Vista and Salida, occur in the granite not far from the mines and veins in that region.

Again some mining districts where we might most expect them are singularly without hot springs. Cripple Creek, for example, whose mines are located in the heart of an old volcano, is destitute of hot springs. When the fissure veins of Cripple Creek were in process of forming and filling, the region was doubtless steaming with hot springs, but these have long since exhausted their energies in filling fissures with quartz and ore and are passed into the crystallized state.

If the Cripple Creek volcano still retains its heat at a moderate depth from the surface and within reach of percolating surface waters, we might naturally expect hot springs to rise and appear, or that the waters which so greatly trouble Cripple Creek's deep mines would show some elevation of temperature. Might we not also expect occasional earthquakes and earth tremors if the Cripple Creek volcano is still hot below, or again, are we to assume that these old volcanoes are, at depth, no hotter or more eruptive in character than the granite surrounding their throats, and that the volcanic heat and forces have left them for other regions and for pastures new.

As an example that hot springs are not necessarily connected with direct manifestations of volcanic energy, but may derive their heat from their depth, we may mention the long zone of hot springs, which runs for miles parallel with the steep scarp of the Western face of the Wahsatch Mountains in Utah. These hot springs are along the line of a profound fault at the base of the mountains, not characterized by any great volcanic display or eruption of lava.

A brief review of the geological conditions and surroundings of some of the best known hot springs in Colorado, will, we think, show 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.

Along the Eastern foothills of Colorado there are few springs that rise above the normal temperature. At the entrance of South Boulder Canon is a warm spring with the temperature 83 to 84 degrees F., near the surface. This spring, or zone of springs, occurs at the juncture of the overlying impervious marly beds of the Jurassic, with the underlying coarse, porous and much fractured quartzite beds of the Triassic. The district is noted for the occurrence of some great mountain faults, such as have produced the twin peaks of South Boulder. The throw of one of these faults is estimated at 3500 feet. It is a reverse fault, due to great compressive force and everywhere the rocks give evidence of such compression by being intensely jointed and checked up. The enormous thick and lofty body of the Triassic quartzite shows evidence of metamorphic heat in its uplift, being locally changed from a normal sandstone or conglomerate to a hard red quartzite. There are no volcanic rocks in the neighborhood nearer than the Dike of Valmont, some six or eight miles east.

Passing from the foothills to the heart of the mountains at Glenwood, on Grand River, we find a number of hot springs issuing from the bed and bank of the river. These hot springs were formerly much higher up than at present, as shown by the hallowed out fissures and joints and little caverns high on the cliffs above the river. The cutting down of the canon by the river lowered the surface exit and position of the springs. These springs occupied a much compressed, sheared and faulted zone of of Paleozoic rocks. There is no volcanic rock in immediate association with them though the little Dotsero crater is on the other side of the mountain, about twenty miles distant, at the junction of the Grand and Eagle Rivers, and some distance south of the springs the hills are covered with fresh looking lava. In the Dotsero crater it is worthy of note there are no springs of any kind. We think, however, that the heat o these springs is attributable more to the depth of these fissures than to the neighboring manifestations of volcanic energy.

At Steamboat Springs, Routt County, are some thirty hot springs emanating from fissures in much folded and faulted Cretaceous rocks, unaccompanied by any prominent signs of volcanic action in the immediate neighborhood.

At Pagosa, in Western Colorado, are a series of hot springs 148 F., one of which issues from a deep crater-like hole full of dark green boiling water. These springs occur in a zone of fissures in much folded Cretaceous rocks which can be followed for miles by springs of various temperatures parallel with the west flank of the Conejos Range. Paralleling the springs, but at some distance from them, is a zone of narrow basaltic dikes; otherwise the area is not remarkable for extraordinary volcanic manifestations.

The hot soda water of Idaho Springs, with temperature 80 to 120 degrees F., issues from fissures in granitic rocks like those now occupied and filled with quartz and ore, forming the gold and silver veins of the district. There is no prominent porphyry or other volcanic rock in direct association with the springs.

The Chalk Creek Springs, of Chaffee County, issue from the white feldspathic granite of the Sawatch Range, with a temperature of 150 degrees F. At Poncha Pass are 100 springs with temperatures 80 to 168 degrees F. Hot Sulphur Springs, in Middle Park, have temperatures of 117 degrees F. Trimble Hot Springs, with temperature of 130 F., issues from the folded and fissured Paleozoic rocks of the Animas Canon. Springs at Wagon Wheel Gap, with temperature of 140 to 150 degrees F., issue from essentially volcanic rocks of the San Juan Mountains. Hot Springs at Ouray occur in a region of much faulted Paleozoic rocks adjacent to the volcanic overflow of San Juan.

Hartzells Springs, in South Park, issue from the tilted hog-back of the Dakota Cretaceous toward the Southern and most volcanic part of the Park. The temperature is 105 degrees F.

In most of these cases cited, the volcanic element is either absent or inconspicuous, whilst that of the folding, faulting and fissuring of the rocks is the most prominent feature and seems to have most to do both with the origin and heat of the springs.

If we assume a downward increase of heat of one degree for every 64 or 100 feet it is possible, from the temperature of the springs at the surface, to form a rough approximate estimate of the depth of the fissure from which they rose.

Thus the Moffat Springs, at South Boulder Canon, with temperature 84 F., would rise from a fissure, at the rate of 64 feet per increase of 1 degree, 6,000 feet, or an increase of 1 degree per 100 feet would make the fissure 8,400 feet deep.

Temperature.				*At 64 Feet Per | Degree. Depth of Fissure.*		*At 100 Feet Per | Degree. Depth of Fissure.*
Pagosa Springs,	148	degrees	F.	9,600	to	14,800
Idaho Springs	128	"	F.	7,700	"	12,000
Chalk Creek Springs,	150	"	F.	9,700	"	10,000
Poncha Springs	168	"	F.	10,800	"	16,800
Hot Sulphur Springs, Middle Park,	117	"	F.	6,500	"	11,700
Trimble Hot Springs,	130	"	F.	8,400	"	13,000
Wagon Wheel Gap,	150	"	F.	9,700	"	15,000
Hartzells Springs,	105	"	F.	6,700	"	10,500

Some profound fault fissures are known to exceed even the greatest depth here given.

The above estimates, however, are merely to show what would result if we applied the assumed rate of one degree for every 64 or 100 feet descent. But these estimates must be taken only in a most broadly approximate sense. Personally, I am inclined to think many, if not all are too deep. There are so many other factors to be considered which might materially alter or shorten the depth, such, for instance, as chemical reactions, producing local heat at a very moderate depth, or heat retained at moderate depths resulting from rock crushing or slipping, or even in some cases from actual buried volcanic heat.

We have treated the subject from a purely geological standpoint; we should like now to turn it over to the chemist and see what he has to say.

In an able article on the Geysers of the Yellowstone, and on hot springs generally, in Hayden's Geological Survey of the Territories, the matter is summed up thus:

"The heat of hot springs may be due, First—To the internal heat of the earth, which meteoric waters acquire by penetrating the rocks, after which they come to the surface as thermal springs.

"Second—Ordinarily, this heat is simply due to the regular downward increase of heat of the earth of one degree temperature for every 60 feet. The temperature may be lower or higher according to the depth penetrated.

"Third—In regions of mountain corrugation thermal springs are of higher temperature than in undisturbed regions, probably because mechanical movement attending plication increases the amount of heat, and fractures caused allow water to penetrate to greater depths.

"Fourth—Thermal springs occur pre-eminently in regions of eruptive rocks, recent or ancient, and no boiling springs are found outside of volcanic areas, proving that in such area downward increase of heat in rocks is greater.

"Heat increases with depth generally, but may be to a certain extent independent of depth.

"The mere presence of volcanic rocks is not sufficient to cause thermal springs. There are large areas of volcanic rocks in Idaho and Arizona that are destitute of thermal springs. In these cases we may suppose that hot springs that once existed may have cooled and become extinct."