

THE HOT SPRINGS AT OJO CALIENTE AND THEIR DEPOSITS.¹

WALDEMAR LINDGREN.

In view of the general interest which attaches to the relation between mineral deposits and hot springs the following notes are published as a small contribution to the subject.

The thermal springs of Ojo Caliente, situated about 50 miles north of Santa Fe, are well known in New Mexico for their curative power and figure in the earliest records of the territory. They issue in the valley of Ojo Caliente Creek, a tributary to the Chama River, which finds its source in the southern slope of the Hopewell Mountains. The easiest access to the springs is from the Barranca station on the Denver and Rio Grande Railroad, about 10 miles east-southeast of Ojo Caliente.

Barranca is situated on the basaltic plateau 1,000 feet above and 2 miles west of Rio Grande. Below the basalt flow lie the white sandy and even-grained deposits of the Santa Fe marl. The road to the springs soon descends the escarpment of the basaltic mesa, and from this point to the springs extends a wide sandy valley, merging on the south with the valley of the Chama. It is entirely covered by the Santa Fe marl, which underlies the basalt and which presents the uniform and thinly bedded characteristics of lacustrine beds. At every favorable exposure this thin bedding is observed and it has usually a well-defined dip of 20° to 35°. At the springs, which issue on the western bank of the stream, these lake beds are distinctly tuffaceous, sandy and gravelly; the tuff appears to be of andesitic character.

Immediately behind the springs rises a bluff of gneissoid reddish rock, 100 feet high. After ascending this the trail to the mineral deposit crosses a little flat mostly covered with sand and about 4,000 feet wide. Beyond this rises boldly a range of

¹ Published with the permission of the Director of the Geological Survey.

hills of reddish gneiss, forming a southerly outlier or extension of the Hopewell Mountains, which consist of pre-Cambrian rocks. The highest points are probably at least 1,000 feet above the springs. The trail follows up a prominent gulch in these hills and the spring deposit is reached at an elevation of about 500 feet above the springs. A small shaft is located on the brow of the hill, south of the gulch, and about 200 feet higher than its bed. A tunnel is driven in the side hill 150 feet lower than the shaft and only a few hundred feet distant horizontally. This tunnel has not yet reached the deposit. Nearby are some irregular excavations which are believed to have been made by aid of fire setting during the early part of Spanish occupancy. These openings, it is stated, were driven on a stringer of the main deposit.

The country rock of the bluff behind the springs and the whole range of hills so far as examined is a reddish fine-grained gneiss, with foliation striking N. 45° E. and traversed by dikes of coarse pegmatite. The microscope shows it to be a mosaic of quartz and orthoclase with a few larger quartz grains; in places it contains microcline, albite, and microperthite in small grains. The gneissoid structure is shown in the parallel arrangement of small flakes of greenish brown biotite or small foils of muscovite.

The shaft is sunk on a distinct vein, in gneissoid rock. The strike of the vein is N. 70° E. and the dip 70° N. N. W.; its width is 2 to 3 feet, and it is traceable for about 200 feet on each side of the shaft. The walls are fairly defined, but the fissure is full of rock fragments which are loosely cemented by crusts of colorless fluorite. The mineral is not readily recognized, for besides being colorless it has a coarsely fibrous structure, perpendicular to the fragments of rock which it encrusts; it looks somewhat like aragonite. The vein matter is oxidized, containing limonite and oxide of manganese, the latter reported to contain silver. Two stringers filled with fluorite come in from the foot-wall side. From the dump of the tunnel were obtained some little stringers in gneiss, filled with greenish fluorite of normal appearance and occasional crystals of barite (011.110.100 according to

W. T. Schaller). The fissure-filling is reported to contain gold and silver. The owner, Mr. Antonio Joseph, who also is the proprietor of the springs, states that the best assay returns yield \$75 in silver and \$30 in gold to the ton, other returns giving, for instance, \$4 in gold and \$1 in silver, and there is no reason to doubt that these figures are authentic. Samples of the crusted fluorite ore were assayed with great care by Ledoux and Company of New York, and yielded traces of gold and silver.

Five hundred feet southwest of the shaft and directly in the line of the vein which can be traced in this direction for 200 feet, is a small hill about 75 feet vertically above the shaft. The top of this hill is covered to the extent of about half an acre by a tufaceous hot spring deposit, probably only a few feet deep. A pit 3 feet deep has been sunk in it. It is a loosely coherent cellular mass, mainly composed of calcite with some limonite. According to Mr. Joseph it contains traces of gold and silver. Three specimens, from the surface, and 2 and 2½ feet below the surface respectively, were assayed by Ledoux and Company with special precautions, and yielded as follows per ton: number 68 Au 0.0008 ounces, Ag 0.08 ounces; number 69 Au 0.0025 ounces, Ag 0.1 ounces; number 70 Au 0.0008 ounces, Ag 0.05 ounces.

A sample of the tufa was analyzed by Mr. George Steiger with the following approximate result:

Insoluble 3 per cent.; Fe_2O_3 , Al_2O_3 , 2.9 per cent.; CaO 50.8 per cent.; MgO none; CO_2 (calculated) 39.6 per cent.; P_2O_5 none; Fluorine 0.44 per cent.; Arsenic none; barium none. The determination of fluorine was made with particular care. This composition corresponds to about 89.60 per cent. of calcite and 0.9 per cent. of fluorite.

The bluff of gneiss immediately back of the hot springs was found to contain at several places narrow, filled seams of a white mineral which proved to be fluorite.

The conclusions drawn in the field from the facts observed were:

1. That the tufa deposit on top of the hill has been accumulated by the evaporation of hot waters reaching the surface.

2. That the vein formed the conduit through which the hot waters reached the surface and in which calcium fluorite was deposited, while the remaining calcium was held in solution as bicarbonate until reaching the surface. The evidence upon this point is strong, but perhaps not absolutely conclusive. The peculiar structure of the fluorite itself tends to show that it has been deposited under unusual circumstances and probably close to the surface.

3. That the tufa deposit and the fluorite vein had been formed by the Ojo Caliente Springs while issuing at a level several hundred feet above the present springs.

4. That the gulch adjacent to the vein and the whole valley had been eroded since the time when the springs issued at high level.

5. That the fluorite veinlets in the bluff back of the springs, and about 100 feet above them, were formed during the gradual recession of the thermal waters, keeping step with the excavations of the valley.

It is needless to say that the assays and analysis of the spring deposit strengthened these conclusions.

Upon the return from the field it was found that a very careful analysis of the waters of the Ojo Caliente Springs had been made a number of years ago, by Dr. W. F. Hillebrand. Several older analyses, evidently of less accuracy and detail were made by Oscar Loew, analyst of the Wheeler Survey, and they agree well, within limits, with Dr. Hillebrand's work, and show that the composition of the springs is approximately uniform. Their temperature is said to vary from 90° to 122° F.

The analysis follows:

The water also contains traces of arsenic, nitrates, iodine (?), barium and ammonium. No organic matter is present. Titanium, bromine, manganese and sulphides were looked for but not found.

This analysis shows that the water is of the sodium carbonate type with minor amounts of chloride and sulphate of sodium. Particularly remarkable is the large and unusual content of fluo-

ANALYSIS OF WATER FROM OJO CALIENTE, NEW MEXICO.¹

BY W. F. HILLEBRAND.

Found. Parts Per Million.		Hypothetical Combination. Parts Per Million.		Per Cent. Total Solids.
SiO ₂	60.2	LiCl	20.9	.62
SO ₄	151.0	KCl	59.9	1.76
PO ₄	.2	NaCl	305.5	9.01
CO ₃	2153.5	Na ₂ B ₄ O ₇	5.4	.16
B ₂ O ₃	4.2	Na ₂ SO ₄	223.3	6.59
Cl	231.4	Na ₂ CO ₃	1846.9	54.49
F	5.2	Ca ₃ P ₂ O ₈	.3	.01
Fe ₂ O ₃ ²	1.6	CaF ₂	10.7	.32
Al ₂ O ₃	.5	CaCO ₃	43.0	1.27
Ca	22.8	SrCO ₃	2.4	.07
Sr	1.4	MgCO ₃	33.2	.98
Mg	9.5	SiO ₂	60.2	1.78
K	31.4	Fe ₂ O ₃	1.6	.05
Na	995.1	Al ₂ O ₃	.5	.01
Li	3.4	CO ₂ (bicarbonate)	775.6	22.88
	3,671.4		3,389.4	100.00

rine, corresponding to nearly 11 parts per million of calcium fluoride. The content in boron is also noteworthy. On the whole, it is a strong mineral water distinctly of the type of volcanic springs; *i. e.*, of hot springs that are common in regions of expiring volcanic activity. No one may question the competency of this water to deposit fluorite and also calcite, on the evaporation of excess carbon dioxide.

The evidence of erosion here adduced tends to show that these springs have been active over a very considerable period of time, possibly since the middle or later part of the Tertiary. The material eroded during the recession of the spring level was probably in large part the tuffs of the Santa Fe formation, which once filled Ojo Caliente Valley. Near Barranca station the top of these lake beds is at an elevation of about 6,800 feet. The elevation at the present spring is 6,292 feet (Wheeler); consequently it must be admitted that at one time, probably at the close of the Tertiary, the lacustrine beds reached the level of the tuffaceous spring and the fluorite veins.

At the present time the springs issue at the foot of the hill

¹ Bull. U. S. Geol. Survey, No. 113, p. 114.

² State of oxidation unknown; Fe₂O₃ all in sediment.

or gneiss, but emerge from the soft sands and tuffs. No deposits of consequence can now form where the springs issue, owing to the manner of their utilization for medicinal purposes.

A number of hot springs, particularly those similar in composition to the type described above contain fluorine. Among those richest in this element are the Vichy Springs, some of which contain from 7.6 parts of fluorine per million up to 18 parts per million. The waters of the spring at Bourbon-l'Archambault are stated to contain 2.68 parts per million of fluorine.¹ In very few instances, however, has the actual deposition of fluorite by hot waters been demonstrated. Daubrée² mentions only two cases, at the Carlsbad and at the Plombières springs.

¹ Clarke, F. W. The data of geochemistry, U. S. Geol. Survey, Bull. No. 330, 1908, p. 149.

² "Les eaux souterraines à l'époque actuelle," 1887, Part II., pp. 19-20.