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DISCUSSION

This department has been established by the editors in order to afford to those interested in questions relating to economic geology an opportunity for informal discussion. Contributions are cordially invited either in the form of discussion of more formal papers appearing in earlier numbers or bearing upon matters not previously treated. Letters should be directed to the Editor, Sheffield Scientific School of Yale University, New Haven, Conn. The full name of the author should be attached to all communications.

THE ABNORMAL TEMPERATURES ON THE COMSTOCK LODE.

Sir: In the late seventies, according to Church, the air issuing from the Comstock mines had a temperature of 92° F. The increase of rock-temperature is one degree for about 30 feet of depth. The bottom levels have yielded water as hot as 170°.

As to the source of the abnormal part of the heat, the prominent possibilities are as follows:

1. Rock-decomposition, particularly hydration. (Church.)
2. The volcanic wall rocks of the lode.
3. Hot springs ascending on the lode. (Becker.)[1]
4. The friction of the lode-faulting.

THE SIGNIFICANT DATA.

To get significant data of the underground temperatures is, as Becker points out, a difficult matter; for these temperatures are deranged by the presence of the mine workings which make possible the presence of the observer. Moreover, evidence, to be at all conclusive, must be both abundant and well studied. Thus, the instances cited by Church regarding the rise in rock-temperatures after the advent of water are valueless as proof of the generation of heat by hydration, because the incoming water was

[1] G. F. Becker, Monograph 13, U. S. Geol. Survey, 1888.

itself hot. And again, the doubtful conclusion to which some of Becker's observations pointed—namely, that the water was hotter than the rock—could not be accepted, even were it well supported, as a final argument that the water was, in general, the source of the heat; for water constantly drawn from the interior and uncooled portions of a rock-mass, must, in any event, have been hotter than those portions of the rock-mass which were accessible to the observer, and which were, therefore, almost certainly cooled.

The unquestionable, pertinent facts are these:

1. At or near the lode, the temperature varies directly with depth.

2. Along the Sutro tunnel[1] the temperature varies with the nearness of the lode and is largely independent of the depth below the surface.

3. The circulation of water within the lode is eccentric: generally, a given locality has been sealed off from others by clay seams, the cutting of which has occasioned serious floods.

4. The water found in the upper levels was cold.

5. Rock and water were almost everywhere nearly the same temperature.

6. Water in large quantities occurred at shallow depths.

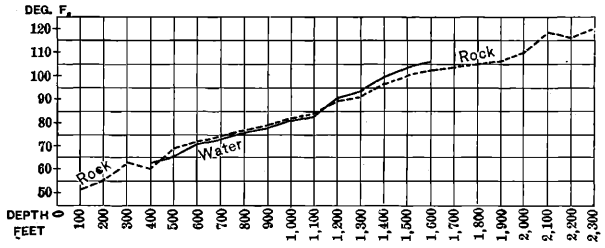

FIG. 75. Temperatures in Foreman Shaft (After Becker)

7. The croppings have never yielded springs of any considerable size.

8. After the emptying of a given level, the level was dry, un-

[1] The tunnel cuts the lode 20,000 feet in and 1,600 feet below the croppings.

less a clay seam of the sort mentioned above was cut. In the interval between the cessation of pumping operations and their resumption (from the early '80's to 1899) the water level stood ten to fifteen feet below the tunnel level in the C. & C. shaft, and the flow from the tunnel was normally between eleven and thirteen miners' inches, though, during the spring, and at times during the winter, it was somewhat more than this. (This information was furnished by Mr. F. O. Broili, superintendent of the tunnel.)

THE FIRST TWO HYPOTHESES AS TO THE SOURCE OF THE HEAT.

That the temperature along the line of the Sutro tunnel varies with the nearness of the lode, necessitates the conclusion that the heat, or, at least, its abnormal increment, emanates from the lode-locality, effectually disposing of the possibility that it is a relic of the volcanic heat of the wall rocks.

The other three hypotheses are thoroughly harmonious with this conclusion. But the hypothesis of Church is no more than a conjecture, devoid of supporting evidence. Moreover, experiments by Barus, recorded in Becker's monograph, indicate that, under the conditions existing on the Comstock, the rocks do not liberate heat by hydration.

THE HYPOTHESES OF HOT SPRINGS AND FAULT-FRICTION.

Of the two remaining hypotheses, Becker's has received by far the greater consideration, and, altogether, it is the one which appeals the more immediately to the attention; for hot springs are abundant in this part of Nevada.

If the heat is actually derived from hot springs, however, these springs possess some remarkable characteristics. First, they have an exceedingly feeble flow—so feeble, that once the water level was brought down below that of the Sutro tunnel, it never later rose to that level, even after pumping had ceased: and again, so feeble, that the water of the upper levels has always been cold. In the second place, the springs must have a very restricted circulation; for the several bodies of hot water exist, we may say,

in several vessels, lacking communication with each other. Nevertheless, the temperature change from point to point adheres to a fairly smooth curve. Still again, the water is feebly mineralized, and contains no ingredient which might not perfectly well have been derived from the solution of the lode materials. True it is that Becker mentions an instance of the evolution of H_2S from water struck in a certain deep level. But this instance is poorly authenticated, and its absolute solitude argues against

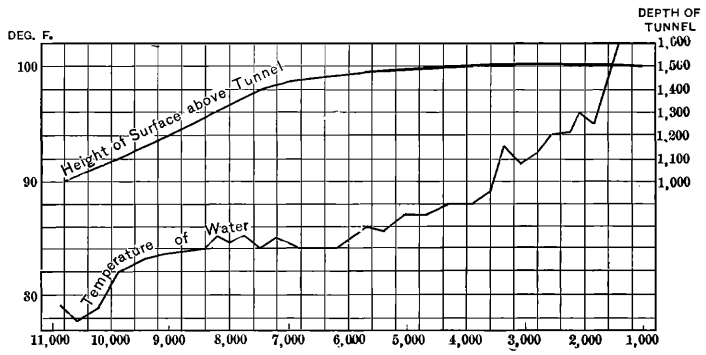

FIG. 76. Sutro Tunnel; Water Temperatures. (Adapted from Becker)

it. Lastly, the water and the materials containing it are of almost identical temperatures. Did the containing materials derive their heat from hot water ascending in any considerable volume, it would seem likely that, at least near the surface, they would lag considerably behind the water in temperature.

We are reduced, then, to two possibilities—either the heat is derived from water of exceedingly slow upward movement, or from the containing materials. I have a slight leaning, which, I must confess, is nothing more than a prejudice, in favor of the second.

But the acceptance of either of these possibilities, and, especially the acceptance of an hypothesis of any detailed source of heat under the second of them, is more difficult than the rejection of all the others. The lode fault has a dip throw of something like a mile, and so, no doubt, generated abundant heat. Yet, later, occurred the lode formation, with the accession to the lode

Analysis of Water from Steamboat Springs, Nevada.[1] Grams per Liter.		Analysis of Water from 2,250-foot Level of C. & C. Shaft, Comstock Lode.[2] Grams per Liter.
SiO_2	0.31065	0.1334
CO_2	.17759	.0150
B_2O_3	.21741	
SO_3	.10389	.3957
S_2O_2	.00307	
S combined as RHS	.00327	
H_2S	.00055	
S	.00052	
Cl	.95243	.0190
Sb_2O_3	.00051	
As_2O_3	.00357	
P_2O_5	.00063	
HgS	trace	
Al_2O_3	.00025	.0025
FeO	.00018	
Fe_2O_3		.0091
CaO	.00958	.1404
MgO	.00047	.0097
Na_2O	.91929	.1765
Li_2O	.01541	
K_2O	.12460	.0643
Cs_2O, Rb_2O	trace	
Total solids	2.84387	.9656

locality of enormous quantities of lode materials, hot at the time of their deposition. Still later, occurred the movement within the lode which produced the well-known "sugar quartz." And we must remember that Church considered only one of the possible heat-producing chemical reactions, and that a very recent one. Perhaps, after all, the now apparently imprisoned hot water may have come in with the lode materials themselves, in which case the ultimate source of its present heat may still have been fault friction.

AUGUSTUS LOCKE.

[1] G. F. Becker, Monograph 13, U. S. Geol. Survey, 1888.

[2] J. A. Reid, Bulletin of the Department of Geology, University of California, Vol. 4, 1905. Analysis by N. E. Wilson.