original writing of those copy ribbons that contained lampblack was permanent, but the copies were not. Copy ribbons failed to give indelible copies because almost none of the carbon was transferred. On exposure of the copy to sunlight for ten days or less, the dye faded out completely, leaving the writing illegible. Most of the ribbons were very satisfactory when fresh, both the original and the press copy being good, but marked differences in the quality of the records were developed by wear, a number which gave good results at first being quickly exhausted.

From the foregoing it may be seen that ribbons of different makes differ widely in their properties; that ribbons of the same make differ as widely; that the ribbon itself is of uneven construction; that the fabric, more than the ink, is the cause of these variations; that many record ribbons furnish permanent records and that much is yet to be desired in the attainment of truly indelible copy ribbons. It is evident that there is need for definite requirements to regulate the purchase of typewriter ribbons, especially as regards the material which is employed as a basis for the ink. An essential of a good ribbon is that the fabric be of the quality best fitted to endure the special kind of service required until all ink available for good writing is exhausted.

AN ANALYSIS OF THE WATER OF DEATH GULCH.

BY G. B. FRANKFORTER.

Received February 7, 1906.

PROBABLY no other spot of the same area in the whole world furnishes such a wealth of natural waters as our Yellowstone National Park. Within its bounds may be found waters containing carbonic acid gas, silicic, boric, sulphuric, hydrosulphuric and even free hydrochloric acid, in addition to salts of nearly all of the metals ever found in any natural water.

One of the most remarkable waters in the park is that of the little stream which flows down through a narrow ravine into Cache Creek. This ravine is now known as Death Gulch. It was discovered by Walter H. Weed in 1888 while exploring for the United States Geological Survey and fully described by him in *Science*. In 1898 it was visited by Dr. Jaggar who found in the gulch the remains of a number of animals including seven grizzlies. Later, it was visited by Captain Critenden who found no remains of animals nor evidences of obnoxious gases. In 1898 Lieut. Lindley found the remains of several bears and indications of gases which produces dizziness and headache. F. W. Traphagen also visited the gulch and found the remains of bears and other animals. He made an examination of the air and found a large amount of carbon dioxide, and the gas which escaped from a crevice contained about 1 per cent. of hydrogen sulphide and more than 50 per cent. of carbon dioxide.

Death Gulch is located in the extreme northeastern part of the park on the Cache Creek about two miles above its confluence with the Lamar river. Owing to inaccessibility, comparatively few persons have visited it. My attention was called to it several years ago while visiting the park but being completely out of the tourists' route, I was unable to visit it. However, Mr. A. D. Hall, a geologist who has spent every summer for a number of years in the park and explored almost every foot of ground, visited the gulch several times. He had no difficulty in recognizing the gulch from the description of those who had visited it before him, but more easily was it recognized by a number of carcasses of bears and other animals which had perished by poisoning, either from gas or water, presumably the former.

Mr. Weed describes the gulch as a simple V-shaped trench not over seventy-five feet deep, cut in the mountain slope and not a hollow or cave. That the gas at times accumulates in the pocket at the head of the gulch, is, however, proved by the dead squirrels, etc., found on its bottom. Having made tests for carbonic acid gas with negative results, Mr. Weed says:

"It is not probable that the gas ever accumulates to a considerable depth, owing to the open nature of the place and the fact that the gulch draining it would carry off the gas which would, from its density, tend to flow down the ravine." Mr. Hall likewise questions the accumulation of any great amount of gas in the gulch and gives as an additional reason the rapid diffusion of the heavy gas with the air, caused by the wind blowing up the gulch. The rocks through which the stream has cut its way are described as volcanic, partially disintegrated and apparently filled with sulphur. The bed of the stream is estimated as having a declination of about 40°, and the sides of the gulch an average of not over 60°. Mr. Hall states that he failed in every visit to recognize the slightest odor of hydrogen sulphide. However, animals which were placed in the gas as it escaped from the crevices in the rocks, perished in a short time.

While there can be no doubt concerning the escape of obnoxious gases from the crevices in the rocks, it was nevertheless thought, from the above topography and the fact that gases could not accumulate in large quantities as in the case of Death Valley, in Java and Grotto del Cane, near Naples, that the water in the gulch might possibly play a part in making the gulch a natural bear trap. Samples of water were therefore collected at various times and examined. They were found to vary widely, depending upon the quantity of water in the gulch. In the spring when the snow is melting and the little stream becomes a good-sized mountain creek, the water is entirely different from that found in the gulch in the fall. In late summer, the stream is almost dry.

The sample of water, an analysis of which appears below, was collected in August 1903. It was taken from a pool near which were crevices in the rocks and from which a perfectly odorless gas escaped. The water was strongly acid.

An analysis gave the following:

	Grams per liter.
SiO_2	0.8100
Al	1.9438
Fe	8.3173
Ca	0.3142
Mg	0.0080
Na	0.9069
K	0.1489
SO_4	42.2904
Cl	1.0326
	55.7721

When collected, the sample had a peculiar yellowish green color. After standing several months it became darker in color and somewhat resembled commercial sulphuric acid. At the time of the analysis, the iron was all in the ferric form. After two years, a further change had apparently taken place. The specific gravity was a little less, being 1.05156, and there was a deposit in the bottom of the bottle. This precipitate was examined and found to be composed almost wholly of free sulphur and silica. In discussing this matter with Mr. Hall who collected the sample, it was found that most of this precipitate was suspended matter at the time of the taking of the sample, but owing to the finely divided state and the dark color of the water it escaped notice unless the sample stood quietly for some time. The bottom of the pool was covered with this precipitate or milk of sulphur. It is therefore possible that it may have come from hydrogen sulphide, although there was no evidence of the presence of the gas when the sample was taken. Tests for the presence of arsenic and the rare elements gave negative results.

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VAPOR-PRESSURE AND CHEMICAL COMPOSITION.

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Received March 27, 1906.

ACCORDING to the theory of corresponding conditions, the calculation of the vapor-pressure curve is possible by means of some equation of the form

$$\frac{p}{\pi} = f\left(\frac{T}{\tau}\right)$$

where π and τ represent the critical pressure and critical temperature respectively. $f\left(\frac{T}{\tau}\right)$ is then a temperature function which is independent of the nature of the substance under consideration. Van der Waals[1] gave, as a first approximation to this function, the form

$$\log \frac{\pi}{p} = a\left(\frac{\tau}{T} - 1\right) \quad . \quad . \quad . \quad (1)$$

where a has the same value for all substances. Van der Waals found this to be about 3.0. Considering the simplicity of the formula, the approximation is remarkable; yet the values of a are not the same for different substances and the values vary somewhat also with the temperature.

To investigate this point more fully Nernst[2] plotted curves for a number of substances, using values of $\log \frac{\pi}{p}$ as ordinates and of $\frac{\tau}{T} - 1$ as abscissae. It was found that the slope of the curves increases quite regularly with the molecular weight of the substances. It is at least apparent that the curves of all substances do not fall together into a single straight line as the theory of

[1] Kontinuität, p. 148.

[2] Nachrichten Kgl. Ges. Wiss. Göttingen, 1906.