costly and discouraging to prompt shippers; that it leads to slow movement of loaded cars and to non-movement of empty cars; that it is not practised in other countries, nor does any like practice obtain in any other business in this country. The *per-diem* basis, on the contrary, is perfectly practicable, as proved by two years' trial on the Union Pacific, and Chicago, Burlington, and Quincy railroads, and its use in a modified form in two European countries.

At noon the convention adjourned. The rest of the day, and Saturday, were given up to the very pleasant excursions and entertainments furnished by the people of the vicinity.

If one-half as much is done to render the coming meeting of the American association pleasant, those who attend will find themselves well entertained.

SOME GEYSER COMPARISONS.

HAYDEN'S twelfth annual report, published by the U. S. interior department, has been in the printer's hands for some time, and will doubtless be shortly issued from the government printing-office. Part ii. of this report relates to the Yellowstone national park, and in it the hot-springs are fully described, and the geology and topography of the park treated of in detail.

It is proposed here to point out briefly some of the differences in relation to geysers between the results of the work in the park and those reached by Bunsen in his study of the Iceland field. It is not necessary to present Bunsen's conclusions in detail, nor to describe his theory, with which doubtless the majority of the readers of SCIENCE are familiar.

Bunsen's conclusions, as presented here, are mainly the same as stated by LeConte in his Elements of geology, although not considered in the same order.

1. Bunsen found in Iceland two kinds of springs, viz., *acid springs* and *alkaline carbonate springs;* and he says that only *alkaline carbonate springs* become siliceous, and that only silicated springs form geysers.

2. The silica in solution does not deposit on cooling, but only by drying.

Our observations in the Yellowstone national park in the main verify this last conclusion, and it is inserted, because LeConte takes exception to it as follows: "This, however, is not true; for the Yellowstone geyser-waters, which[1] deposit abundantly by *cooling*, evidently because they contain much more silica than those of Iceland."

[1] This is evidently a grammatical error.

The following table gives the results of the observations in the park as far as they have been made in regard to the points just enumerated.

Name.	Character of spring.	Grains of silica to imperial gallon.	Reaction of water.	Condition of water after three years, when bottles were opened.
Jug . .	Quiet spr'g,	14.56	Alkaline,	Perfectly clear, no deposit.
Echinus .	Geyser . .	10.60	Acid . .	Perfectly clear, no deposit.
Pearl . .	Geyser . .	7.84	Alkaline,	Clear, with small deposit of gelatinous silica.
Opal . .	Quiet spr'g,	53.76	Alkaline,	Opaline as when bottled, no deposit in bottle.

Here, then, we have an alkaline spring and an acid spring, both of which are geysers. We see, also, that the mere fact of cooling has little to do with the throwing down of the silica, nor does the precipitation appear to be due to the amount of silica held in the water. Ordinarily the formation of siliceous sinter or geyserite must be explained by the evaporation or drying of the water as it flows from the springs, or falls from the geysers.

The chimney-like form is very noticeable in the craters of the Yellowstone geysers; and LeConte attributes it to the greater abundance of silica in solution in the waters of the Yellowstone geysers.[1]

As a fact, however, the analyses already made of geyser-waters from the park show usually a smaller percentage of silica than do those of Iceland. Opal spring (see table above) is an exception, and it is a spring without the least appearance of a crater or chimney. The real explanation is probably in the greater age of our geyser region.

3. Bunsen's conclusions as to temperature are as follows: —

a. The temperature increases with the depth of the tube.

b. At no point in the tube does the water have the temperature of ebullition which it should have under the pressure to which it is subjected.

c. The temperature depends on the time that has elapsed since the last eruption; and, as a great eruption approaches, the nearer it comes to the boiling-point.

d. At a depth of forty-five feet in the Great geyser, the difference between the observed temperature and the calculated boiling-point of the water for that depth and pressure was the least.

[1] Elements of geology, p. 104.

In the Yellowstone national park, wherever deep temperatures were taken in active springs and geysers, they were found to increase with the depth; but temperatures of ebullition were found at the surface of many springs, and in some the temperatures exceeded the boiling-point. As the time for an eruption in a geyser approached, the temperature increased, which fact agrees with Bunsen's observations.

In 1865 a Mr. Bryson of Edinburgh found that the tube of the Great geyser of Iceland has a ledge about forty-five feet below the top of the tube, and that, from beneath this ledge, steam-bubbles rose while the tube was filling. A thermometer sunk to this point was violently dashed about and broken, but, when sunk below it, was quiet and undisturbed. The conclusion is, that here is an opening by which steam and superheated water have access to the main geyser-tube from the side. Similar side-openings are known to exist in Strokhr; but the Great geyser is so full of water that its structure cannot be so readily studied as in the case of the smaller Strokhr. In Bunsen's theory this point forty-five feet below the surface plays an important part. He allowed his thermometer to remain at the bottom of the geyser-tube during a great eruption, and it was undisturbed. Mr. Bryson's discovery explains its safety. It was below the active side-vent of the geyser.

Bunsen's conclusion would therefore probably have to be modified so far as relates to the temperature of ebullition not being reached; for, could he have obtained temperatures in the side-conduit, there is but little doubt that the boiling-point would soon have been reached, even for the pressure of that depth. The mass of water in the main tubes prevents that condition at the surface; and, when it is attained opposite the aperture, an eruption occurs.

Bunsen's theory of the formation of geyser-tubes also requires some modification. Contrary to his opinion, the deposit of silica is not necessary for geyseric action. In the Gibbon geyser basin in the national park are several geysers conspicuous from the small amount of siliceous deposit surrounding them; and one in 1878 was entirely without a deposit, having just broken out as a steam-vent. By the following year it had settled down to regular geyser action.

As already mentioned, there are, in the park, geysers the water of which is acid in reaction; and therefore the theory that before developing into a geyser the spring must pass through a preliminary tranquil or non-eruptive stage (in which it is an acid spring) is not warranted by the facts observed in the Yellowstone region. It is probable that all geysers are originally due to a violent outbreak of steam and water, and that the first stage is that of a huge steam-vent. Under such conditions, irregular cavities and passages are more likely to be formed than regular tubes. The lining of the passages and tubes takes place afterwards, and is a slow process. Whether the subterranean passages in which the water is heated are narrow channels, enlargements of tubes, or caverns and tubes, is probably of little consequence, except as the periods or intervals of the geyser are influenced. If water in a glass tube be heated rapidly from the bottom, it will be violently expelled from the tube, or, if boiled in a kettle that has a lid and a spout, either the lid will be blown off, or the water will be forced out of the spout. In the first case we have an explanation, in part at least, of Bunsen's theory; and the second exemplifies the theories which presuppose the existence of subterranean cavities and connected tubes. The simpler the form of the geyser-tube, the less is the impediment to the circulation of the superheated water; and in this fact lies the explanation of the difference between constantly boiling springs and geysers. The variations and modifications of the subterranean water-passages, however, must be important factors entering into any complete explanation of geyseric action.

Bunsen's theory, somewhat modified, is probably the best yet proposed, especially that part of it which explains the effect of the rise of water nearly at the boiling-point to an upper portion of the channel where its temperature is in excess of that necessary to cause ebullition. The excess of heat is violently and instantaneously applied to the production of steam. McKenzie, in 1810, also recognized the fact that the sudden evolution of steam was the proximate cause of the eruptions; but he could not account for their periodical production.

The water of geysers and hot-springs has been boiled and reboiled for an inconceivable period, and is freed from air as no other water is. Its cohesion is therefore immensely increased; and this fact, together with the obstruction to the free escape of steam caused by irregularities in the channels, offers a complete explanation of the superheating of the water; and it is well known, that, when water so heated does boil, the production of vapor is instantaneous.

A. C. PEALE.