Note on the Lava taken from the Halemaumau Pit by Mr. Frank A. Perret in July, 1911, with gas analyses and remarks by Albert Brun.

In the accompanying article, Mr. F. A. Perret shows that he has been able to get, out of "Old Faithful," lava still in a state of fusion. This interesting experiment, carried out with much skill, made it possible to study in the laboratory a lava which was taken when in the midst of the process of evolution. The points which I examine in this note only include a few facts relating to the gases, as well as those relating to the action of steam on the magma. In addition I also examine a special feature in the evolution of crystallization of the melted magma of Kilauea.

Gases.—It is well known that, during the last century, the French astronomer, Jansen, discovered with the spectroscope, that the flames which escaped from the lava lake of Kilauea gave the spectrum rays of sodium, C, and H_2. The gas analyses published during recent years by myself in my book "Recherches sur l'Exhalaison volcanique" (1911, page 115) confirm this composition. The lava in fusion obtained by Mr. Perret in 1911 also gives out gases, the nature of which confirms the above mentioned analyses.

To extract the gases, I heated the glassy lava in a vacuum nearly to the melting point, or to complete fusion. This operation took place in an apparatus already described. It distils quite a quantity of hydrocarbides which are condensed in the form of black bituminous rings which colored P_2O_5 yellowish brown. It also deposited a white ring of (Na,K)Cl and NH_4Cl which can be easily analysed. It is known that the composition of a complicated mixture of gases is influenced by the duration of the time of heating, the temperature, the pressure and the partial pressure of each individual gas, so that the final result is somewhat variable, even with the same materials. But the importance of this slight variation need not be exaggerated.

The lava collected by Mr. F. A. Perret gives off the following gases:

A—Lava heated to complete fusion for a long time; from 1 kilogram of lava.

Solid matters:

Chlorides (Na,K)Cl volatilized, milligrams			75
Salmiac (NH_4Cl)	id.	id.	15
Bitumen			very abundant

Gases: Quantity in cubic cent. 310cc

Contained	Cl_2	traces
	HCl	4·6
	SO_2	14·4
	CO_2	67·0
	CO	8·
	H_2	5·
	N_2	1·
		100·0

I have explained elsewhere the presence of CO. The examination of the composition of these gases, as well as of the substances volatilized and easily condensed at the ordinary temperature, shows immediately that a great part is combustible. On coming into contact with the atmosphere these substances will burn, owing to the high temperature which they possess on leaving the magma in fusion. Therefore there will also be formed CO_2, and water of *extra magmatic origin.*

This, therefore, easily explains the flames, giving more or less light, which observers have seen rising from Lake Halemaumau. It is also advisable to note that these gases contain very little N_2. The percentage of N_2 will always be a criterium of great general importance, which will denote the purity of the gaseous products collected on the spot, either from a fumarole or from the liquid lava.

Oxidization of the Lava (by water).—The lava collected by Mr. F. A. Perret from "Old Faithful" is not completely oxidized. After having extracted all the gases from it, there remains a melted mass of black silicates, opaque even in thin splinters; this mass is rich in C. Therefore the silicate does not contain enough peroxides in order to oxidize all its C at the temperature of the lake. But if we supply the necessary O_2, either in the form of water or air, we shall be able, at the temperature of the lake, to oxidize all the C easily, and to obtain a great quantity of CO_2 and H_2; therefore this experiment proves that the magma did not contain enough water to oxidize all its C.

This demonstration may be made, in a very elegant way, as follows: Let us take the black silicate residue which during the first heating gives off all its gases, and its volatile substances, and which only contained a residue of carbon. This residuum must be heated in a closed apparatus in the presence of steam and nothing else, and without any traces of atmospheric air. A manometer shows the pressure, at every moment, of the gases formed at the given temperature. In the course of the heating a reaction is developed. The water attacks the lava and its carbon. The pressure in the apparatus which I used reached 500 millimeters of mercury at 1000°.

Under the same conditions the gases of lava *alone, without the action of the water*, only give a pressure of 8–10 millimeters of mercury. The gases collected during this intense reaction have the following composition; B, first exp't; C, second exp't:

	Composition of the gases. B	C
SO_2	26·2 (with CO_2)	0·25
CO_2		19·4
CO	5·0	6·4
H_3	68·0	74·0
N_2	0·4	traces
	99·6	100·05

The quantity given off from 1 kilogram of lava depends on the quantity of water. I obtained 4000 to 6000 cubic cent.

It is advisable to remark, that the quantity of gases collected is enormously greater than that obtained by the study of the apparent density of the natural vesiculated lava. In our experiment the water oxidizes the lava continually until the chemical equilibrium is reached. This reaction, which we accomplished in the laboratory, does not take place in the magma of the volcano, for the latter contains a residue of carbon. Therefore, if there was any steam, it was in too small a quantity to attack all the C. The proportion reached so low a limit that it is almost nothing.

This enables us to say: that the magma of Kilauea is anhydric, with the exception of the enclaves, and in special cases, (as explained in my Recherches sur l'Exhalaisoñ volcanique, p. 264,) it even seems that this proposition may be extended to the ancient magmas, such as granites. For we know that white and black micas are not chemically hydrated minerals, as has hitherto been admitted. For the details concerning this proposition, which seem to be extraordinary, see Bulletin de la Société minéralogique de France, Feb., 1913, and Archives des Sciences, Genève, xxv, No. 5.

Crystallization.—We wish to draw attention to the interesting point brought to light by Mr. Perret's skilful experiment. The lava was indeed collected at the very time of its volcanic and crystalline evolution; as before explained, a fairly large mass of lava was extracted from the "Old Faithful." When he got the lava in fusion, from the pit, Mr. Perret brought up a glass in which some crystals were floating (labradorite, peridot, and more rarely augite of old formation). Several of these crystals are in the course of digestion. They are corroded and the edges rounded, which shows them to be debris of enclaves. Other crystals have clear cut and sharp angles: they probably are in the course of formation.

The external part of the block, cooled suddenly, was consolidated into a limpid yellowish-green glass. The internal part, cooling more slowly, crystallized. There were no real crystals, but trichitic-centroradiated spherulites. These trichites are generally developed around a preexisting crystal; they form around it a dark-colored hairy setting, opaque in the center and transparent at the edges. The refractive index is greater than that of glass. The fibers are extremely fine, delicate and indistinct in form. It is easy to recognise, with polarized light, the characters of a spherulite, the fibers of which are elongated optically + (positive).

It is impossible to say whether a pure mineral is present. We are in presence of an intermediate state of crystalline evolution. This phenomenon appears in a very short space of time—a few hours. We must be grateful to Mr. Perret for having demonstrated experimentally, *on the volcano itself*, this interesting epoch in the life of the lava.

The present writer had intended commenting at some length on this most interesting report, especially as regards the question of anhydricity, but lack of space absolutely necessitates deferment of the discussion, which, to have any value, would be long. The results obtained by the writer's successors at Kilauea should throw great light upon the exact nature and proportions of the emanations; the field is a fertile one for direct research, and there can be no doubt that the observatory, now established and in charge of Professor Jaggar, will prove itself an institution of the greatest value to the growing science of volcanology.

Some of the more salient points brought out in the present series of papers on Kilauea.

1. Gaseous cause of the mechanism of lava fountains.
2. Three phases of fountain action distinguished.
3. Air oxidation (burning) of gases emanating from the lava.
4. The burnt gases from visible cloud readily photographed.
5. Islands supported by chilling to them of artificial shore and by gas flotation.
6. Formation of gas ducts to top of floating islands.
7. Formation of sub-surface cavity with lava dis-levelling and production of free flowing cascade.
8. Sinking of islands effected by lava overflows due to rapid changes of level.
9. So called "new islands" often due to chilling of lake surface by re-flotation of sunken island.
10. Circulation of lake initiated by gas explosion, and continued by sinking of heavy surface material.
11. Elongated form of lake necessary consequence of this principle of circulation.
12. Variations in height of lava column slightly influenced by atmospheric pressure changes.
13. More strongly by luni-solar gravitational influence.
14. Pronounced sinking of lava after gaseous outburst.
15. Crater ledges may subside so gradually and by so minute a subdivision as to constitute a "slow flow."
16. Evidence of *many* explosive phases in the past of Kilauea.
17. Characteristically tail-less bombs.
18. "Péle's tears."
19. Strong evidence from native tradition as to antiquity, normal origin, explosive, activity, etc. of Kilauea.
20. Monolithic consolidation of stagnant lava.
21. Shell or tubular consolidation of flowing lava.

22. "Pressure casting" of trees.

23. Permanence of crater and conduit walls, floating islands, etc., due to slowly consolidated lava having higher fusing point by reason of crystallization.

24. Temperature of modern lake shown to be from 1050° to 1175° C—possibly from 1000° to 1200°.

25. Appearance of white heat often due to absorption of yellow rays by transparent burnt gases.

26. Thermo-electric element preferable to electric resistance thermometer for field work.

27. Chemical and physical characteristics of fountain lava collected directly.

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