ART. XVII.—*Some Kilauean Formations*; by FRANK A. PERRET.

THE floor of the great pit crater of Kilauea has an area of more than ten million square meters, every one of which—on the surface, or immediately below it—reveals something of interest or importance to the investigator. To say, therefore, that a month might profitably be devoted to its exploration is almost to state an absurdity—a lifetime would be more appropriate and it is more than probable that, in such an interval, a new floor will have been laid, with fresh interests for the visitor at every step.

The larger portion, by far, of this great area is composed of pahoehoe lava which has overflowed from Halemaumau or welled up through more ephemeral vents—its smoothly undulating, glassy surface glistening with that satiny sheen which is responsible for the peculiarly expressive Hawaiian name. Here and there, however, a long, high-standing AA flow, having a jagged, dark red surface contrasting sharply with the surrounding plain, has made its way along some slight declivity from a now hidden vent from which it had issued tumultuously, hissing with gas at every pore. And, between these extremes, there may, in places, be found an intermediate type passing by insensible degrees from the most superficially incoherent AA to a form so smooth and plate-like as almost to merit the appellation “ultra-pahoehoe.”

In the opening sentence of the present paper a hint is conveyed of interesting things *beneath the surface* and that these exist is due to the fact that this great crater floor is composed chiefly of lava *flows*. A stagnant pool of the Kilauean lava will, in cooling, solidify from the surface to the bottom into a continuous and homogeneous mass of rock, but a flowing stream drains away, after the solidification of its surface layers, leaving a tunnel with an arched roof. The gases which continue to be emitted from the inner, flowing lava, undoubtedly assist in supporting the roof during consolidation and may even form expanded chambers at intervals along the line of a flow. On the crater floor the visitor is thus walking over caverns and tunnels of whose existence he is unaware, excepting in the comparatively few instances where the roof has foundered and revealed the “cave” below. The larger of these are provided with a ladder giving access to the interior and have been given fantastic names, such as “Pele’s Dining Room,” etc. In certain cases they have been observed by the writer to terminate upward in a prismatic cupola almost—and, in some

instances, quite—perforating the roof. If this occurs in the earlier stages of the flow, an active vent is formed, emitting much gas and a little lava in spatters or driblets which build up a “blowing cone” over the orifice. When the action is violent, and especially if the cone has formed at or near the lava’s point of issue on the crater floor, it will take the form of an open cylinder, as in the case of the so-called “Little Beggar” (fig. 1), and the lava stream will then have the appear-

FIG. 1.

FIG. 1. The “Little Beggar” blowing cone.

ance of flowing from the base of the cone. A more moderate activity forms a simple “driblet cone” (fig. 2) in which the central conduit may be closed at the top by the last splashes emitted therefrom.

These spatter cones have always constituted a conspicuous feature of Kilauean volcanism and testify to the importance of the *gaseous emanations* from the active lava, upon which there has been so great a tendency to cast doubt. They are also interesting as demonstrating that the same, ultra basic lava which, flowing continuously, produces a cone with declivities so gentle as not to exceed, in some cases, four or five degrees will, if ejected intermittently in splashes which cement together and have time to cool, result in a construction whose sides may even attain the vertical and thus exceed the repose angle of the

most chaotic of fragmentary ejecta from more acid and explosive volcanoes. The cones often appear upon the newly formed "shore" of the Halemaumau lava lake and are then of the greatest value to the investigator as offering a means—by the introduction of a tube through an orifice of the blow-cone—of

FIG. 2.

FIG. 2. A typical spatter cone.

collecting the gases emanating directly from the active lava and before their modifications by contact with the air.*

Closely allied to the above-mentioned gas-expanded chambers along the line of a flow—and, in some instances, identical

* As has already been shown in preceding papers of the present series, these gases burn on coming in contact with the atmosphere.

with these—are the intumescent formations for which the late Dr. Benedict Friedlaender proposed the appellation “Schollendom” (fig. 3). In many instances these also are gas-expanded or, at all events, gas-supported, during solidification, and Mr. Immanuel Friedlaender has informed the writer of having observed these formations covering vegetation at the bottom of Kilauean-iki. Green has shown* how the characteristic subspherical shape may also result from the simple flowing out of pahoehoe lava in spheroidal masses, after the manner of por-

FIG. 3.

FIG. 3. A typical “Schollendom.”

ridge, upon which the surface cools over until the inner lava forces a way out at the lower side to flow on and form other spheroidal accumulations along the line of the flow.

On cooling, the mass is fissured by contraction and a central block is frequently separated from the rest and founders, revealing the dome in section—often as a comparatively thin roof arching over a void, but frequently also as a monolithic mass as deep as the dome itself (fig. 4).

It is, therefore, incorrect to state that these formations are intumescent by reason of the intrusion of fresh lava beneath a crust already formed and fractured—the Schollendom is a primary formation and is fissured by contraction in cooling. Intrusive lava often *does* uplift the flat slabs of the crater floor, the which are then incorporated with the resulting dribble mound,

* Wm. Lowthian Green : “Vestiges of the Molten Globe,” vol. 2, page 173.

as could be shown photographically were the present paper not already overcharged with illustrations, but such a construction is not a true Schollendom. The writer has also seen already-

FIG. 4.

FIG. 4. Interior section of a "Schollendom."

formed Schollendoms invaded by fresh lava from below but, in such cases, the dome is deformed and its gracefully lenticular outline destroyed.

The general subject of *lava tunnels* must be left to a future paper and the same is to be said of those interesting tunnel products, the stalactites and stalagmites, the consideration of which would require much space and which are here mentioned as constituting a curious—if small and secondary—Kilauean formation. Notwithstanding all that has been written of these characteristic little forms, the main question, viz., their mode of formation, remains wholly unanswered; the various theories

FIG. 5.

FIG. 5. A tree mould of the projecting type.

being indefinite and inconclusive or else incompatible with the revealed characteristics of the product. The subject requires further study and the devoting to it of a separate paper.

Lava flows outside the great crater have, in some localities, produced the very interesting formations known as "Tree moulds." These are divergent in type according to the conditions of the flow of lava. If this has invested a forest of trees, or some great unit in the midst of a plain, and then, in great part, flowed away, a casing of lava—solidified by contact with the cold tree-trunk—will be left surrounding this to a height corresponding with the greatest depth attained by the stream at that point. This remains, therefore, as the *salient*, or *pro-*

jecting type of tree mould, standing above the surrounding plain as a monument to the original tree which, even if not at once destroyed by the igneous flood, has since suffered that decomposition and transmutation which is inevitable at the hand of time. (Fig. 5.)

In the *sunken* or *ground* type the lava has invaded low ground and has remained at virtually its full height around the stricken trees, of whose substance no vestige now remains

FIG. 6.

FIG. 6. Tree moulds of the sunken type.

but whose form, to the most minute detail, is preserved in lasting stone.

The visitor sees a number of cylindrical openings in the ground (lava) descending to the depth of the original flow which, in the cases observed by the writer, was from three to five meters. (Fig. 6.) It is most interesting to note that, at and near the surface, where the lava was not pressed with force against the tree and was also free to slightly shrink away upon cooling, the impression is of the grosser details only, such as the circular or elliptical form of the trunk with the more prominent corrugations while, the farther one descends, the more nearly perfect becomes the imprint of the bark. Near the bottom, where the lava pressed the tree with a force corresponding to the depth of the flow—and which we may

estimate as one kilogram per square centimeter—the impression is as reproduced in fig. 7, than which nothing more exquisitely precise can be imagined. It is a true “pressure casting,” so faithfully recording the finest detail that, from it, a naturalist may readily classify the original tree, of which the lava has thus formed so perfect a matrix.

The reader will marvel that the tree was not marred by its baptism of fire before such an impression could be obtained,

FIG. 7.

FIG. 7. Specimen from a tree mould.

but, if we except the resinous varieties, a growing tree-trunk, massive and full of moisture, will resist carbonization for a time sufficient to permit of the formation of a solidified layer or shell in contact with its surface and which—to make use of an expression almost hackneyed—is “a poor conductor of heat.” Something more than this, however, is required to account for the greater marvel that this mere shell is not then re-melted and destroyed by the flood of liquid lava at full temperature which continues to flow against it and the fact that it is not so re-fused can be explained, the writer believes, in but one way. Careful examination of the mould shows that not even the contact surface is vitreous and it is, therefore, obvious that the consolidation has taken place rather slowly, i. e., it

was not a matter of a very few seconds but of many minutes, as indeed we should infer, considering the backing of a mass of liquid at full heat. The result, then, is a shell of *crystalline rock*, deposited molecule by molecule after the manner of an electrotpe, and whose *fusion point is higher than the temperature of the liquid from which it consolidated*. We may believe, therefore, that there is no power in the flow to re-fuse the crystalline shell deposited therefrom as the lava—especially in the case of a *stream*—will not possess a sufficient degree of superheat to accomplish this; the shell, instead, will progressively increase in thickness.

The writer believes that failure to appreciate this most important fact, viz., that the fusion point of the crystalline rock is above the temperature at which the original lava will remain fluid, has frequently resulted in an exaggerated evaluation of the temperature of liquid lava through the practise of taking the melting point of the consolidated crystalline product as marking the lower limit of the liquid lava's temperature. The Halemauuan lake, for example, is liquid and active at 1050° C., but the rock of its consolidation—according to recent tests by Dr. E. S. Shepherd—melts at 1150° C.

It is the principle—truly universal in its distribution—of relaxation resulting in products which are then with difficulty removable. In the field of volcanism it is this which gives to the crater ledges their stability, to the floating island its span of existence, and which for a time ensures the growth and preservation—as it must eventually set the seal of closure and extinction—of and to no less a formation than the volcanic edifice itself.

Posillipo, Naples, May 6, 1913.