On Fulgurites from Griqualand West.

By Frank Rutley, F.G.S.

[Read October 24th, 1893.]

THROUGH the kindness of Professor D. Hahn of the South African College, Cape Town, I received, some time since, a series of specimens of fulgurites which were collected in the vicinity of Griquastad.

In this locality Professor Hahn informs me that there is a particular sand hill which is noted among the farmers living in the neighbourhood for the frequency with which it is struck by lightning during thunderstorms.

The specimens vary from 3½ to 1½ inches in length, and apparently represent widely separated parts of one or more fulgurites.

Lightning tubes formed in sand have been so frequently examined and described that there seems little to add to the literature of this class of fulgurite. The treatise by Harting[1] is perhaps one of the most important contributions, giving, as it does, a good resumé of all that had been published on this subject prior to the year 1874. Subsequently papers by Roemer,[2] Gumbel,[3] Wichmann,[4] Merrill,[5] and Bayley[6] have appeared, and it is in those by the two last named authors that some statements are made which seem to deserve further consideration, especially those bearing upon the nature and origin of the superficial corrugations and wing-like projections on lightning tubes.

Among the specimens sent me by Professor Hahn are three which appear to possess an especial interest. One of these, about 2¼ inches long, ⅝ inch in greatest breadth, and varying in thickness from that of a sheet of note paper, in the middle, to rather less than ⅛ inch at the sides, consists of two delicate tubes of vitrified sand, which run nearly parallel

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1 "Notice sur un cas de formation de Fulgurites et sur la présence d'autres Fulgurites dans le sol de la Néerlande." *Acad. Royale Néerlandaise des Sciences.* T. XIV. 1874.

2 *Neues Jahrbuch für Mineralogie*, 1876, p. 33.

3 *Zeitschr. d. deutschen geol. Gesellsch*, XXXIV. p. 642.

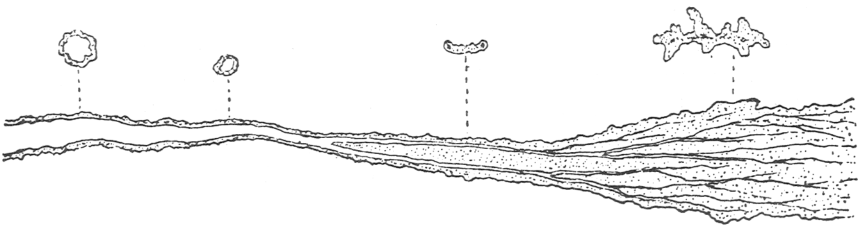
4 *Zeitschr. d. deutschen geol. Gesellsch*, XXXV. p. 849.

5 *Proceedings U.S. National Museum.* Vol. IX. p. 83.

6 *American Journal of Science.* Vol. XLIII. p. 327.

to one another and are united by a narrow band of the same glassy material.

This specimen doubtless represents the continuation of a bifurcated tube, and, judging from the small diameters of the tubes, as compared with those of the larger single tubes from the same locality, which range up to nearly half an inch, it seems probable that they must have been formed at a considerable distance from the point at which the lightning first entered the sand.



The band of vitrified sand which unites them has seemingly originated in the same manner as the external wing-like ridges on the larger tubes, and I quite agree with the views entertained by Mr. Merrill and Professor Bayley that such ridges are not caused by a collapse of the tube, as suggested by Harting.[1]

With regard to these ridges, Mr. Merrill asks, "Is it not more probable that they are formed by the lightning's following out the path of least resistance, causing the bore to be enlarged here and contracted there in accordance with the conductibility of those portions through which it passed and the amount of moisture they contained, and that the small branches and wings, sometimes mere points, are lateral offshoots? The absolute contact, in some cases, of the inner walls of the wings, together with the fluidal structure extending from within outward, as noted by Wichmann, would, it seems to me, tend to prove that they are original structures, and in no way caused by a subsequent collapsing."[2]

Professor W. S. Bayley[3] appears to have arrived at a similar conclusion, for, speaking of these wing-like processes, he remarks, "Throughout

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[1] "Ces rugosités répondent en partie à autant de plis de la paroi du tube. Ces plis peuvent être expliqués de deux manières, soit en admettant que l'effet expansif de la vapeur d'eau n'a pu s'exercer d'une manière égale dans toutes les directions pendant le trajet de la foudre, soit en supposant que le tube, d'abord mou au moment de la fusion du sable, a subi une pression extérieure par le sable environnant qui s'écroulait." *Op. cit.* p. 9.

[2] "On Fulgurites." *Proc. U.S. Nat. Mus.* Vol IX. p. 88.

[3] "A Fulgurite from Waterville, Maine." *American Journal of Science*, Vol. XLIII. p. 328.

their greater extent the wings are merely a single layer of glass, to both sides of which sand grains adhere in large numbers. The continuity of the glass across the corrugations seems to lend credence to the view of Merrill that these irregularities on the surface of sand fulgurites are due, not to the collapsing of the walls of the tube, as suggested by Wichmann, but to the selective power of the electricity in directing its course through the sand. That the corrugations are original structures due to the action of the electric current, rather than accidental ones, is also indicated by their spiral twist."

A thin slice taken transversely through the tubes at one end (Fig. 4, Pl. vii.) of the Griquastad specimen (Fig. 3, Pl. vii.) shows under the microscope that, at all events in the plane of section, there is no communication between the two tubes, the connecting band consisting of clear colourless glass, similar to that forming the tubes and containing numerous steam vesicles.

Harting speaks of the occurrence of what he terms much flattened tubes, the interior walls of which almost touch, so that the passage is partially obstructed.[1] Furthermore, Merrill describes (to quote his own words) " small irregularly rounded lumps of fulgurites without the tubular openings, resembling nothing more than as if a ladle of the molten matter had been poured out upon the ground and 'spattered,' as suggested by Mr. Abbott. The largest of these was some 2 cm. broad and 5 to 6 mm. in thickness."[2]

Two of the specimens from Griquastad (Figs. 5 and 7, Pl. vii.) correspond, to some extent, with this description. The largest (Fig. 7) is 3½ inches long and 1 inch in greatest breadth. Its thickness averages less than $\frac{1}{16}$ inch, but from both of the broad surfaces irregular ridges project up to ¼ inch in height. At one end of the specimen two small tubes open out, each large enough to admit a fine wire. The fractured surface seen at the other extremity is, so far as can be made out with a pocket lens, absolutely closed.

A thin section has been made through a smaller but similar specimen (Figs. 5 and 6, Pl. vii.) from the same locality. In this an irregular tubular opening is visible, where one of the ridges springs from the surface of the irregularly crumpled plate. The remainder of the plate, as well as the apophyses, seems to consist of vesicular glass, without any original cavities other than steam vesicles. It would appear, then, that these thin platy fragments occur near the extremities of fulgurites. The actual

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[1] *Op. cit.*, p. 9.

[2] *Op. cit.*, p. 88.

extremities probably consist of irregularly crumpled or corrugated sheets of vitreous matter in which no tubes exist.

That the irregular rugose plates just described are not portions of the distinctly tubular part of a fulgurite is evident from the fact that they present on none of their larger surfaces the vitreous glaze which characterises the interior surfaces of such tubes, the only vitreous surfaces visible being on the thin fractured ends. That they are not the external ridges or wings of large tubes is equally demonstrable from the fact that no fracture occurs on their long thin edges.

The branching lines in Fig. 8, Pl. vii., are copied from a photograph,[1] made by the spark from an induction coil when the positive pole is brought over the sensitised surface of a glass plate. The plate is perforated by the spark, but a portion of the discharge is dissipated over the resisting surface of the plate.

In addition to the clearly defined branches, delicate streamers of light may be noted in the photograph. These emanate, not only from the margin of the central perforation, but also in a minor degree from the branches themselves.

Assuming that lateral extensions, somewhat similar to those photographed by the electric spark on the sensitised plate, occur at extremely small intervals along the course of a lightning flash when it passes into loose sand, we might represent the distribution of the electric discharge by a succession of photographs, similar to the one already alluded to, impaled upon an irregularly bent wire.[2] The wire would then denote the general direction of the flash, and around this a tube would be formed, the moisture present being converted into steam and the sand displaced and fused by the passage of the lightning.

It seems probable that the inner surface of the fulgurite tube would lie at or near the limit of the finely fibrous fringe proceeding from the centres of the photographs, each of which might be taken to represent the distribution of the lateral portion of the flash about that point in the wire where the latter passed through the photograph. The extremities of the well-defined branches in the lateral extension of the flash would penetrate between sand-grains lying around the tube, and, by fusing those grains, would form the wing-like excrescences which are so characteristic of this class of fulgurite.

The directions of the lateral branches of the flash would probably be

[1] Taken by Mr. Chapman.

[2] The wire passing through the point in each photograph where the sensitised plate had been perforated by the spark.

determined by the contiguity of the larger interspaces between the sand-grains.

Such an hypothesis abolishes the necessity for any theory involving collapse of the tube in order to account for the ridges upon its outer surface. A series of photographs ranged along a wire can necessarily convey but a very crude suggestion of the conditions which influence the formation of a fulgurite of the sand-tube type. The resisting surfaces, along which the lateral extensions of the electric current spread, occur at infinitely small distances, and, in sand, such surfaces would naturally be very irregular.

The border around the margin of Fig. 8, Pl. vii., may be taken as approximately indicating an enlarged transverse section through a lightning tube, the excrescences being formed by the extremities of the branches which constitute the lateral extension of the discharge at any given point.

The bifurcation of lightning-tubes has been noted by Fiedler and by subsequent observers, a small pebble having occasionally been found at the point where the tube forks. Some of the short pieces of tube, such as that shown in Figs. 1 and 2, Pl. vii., from Griquastad, taper to a very marked extent and may represent either a local inflation or a progressive tapering of the tube.

It is noteworthy that the long fulgurite from Drigg in Cumberland, now in the Mineral Department of the British Museum, appears to be of approximately the same gauge throughout its entire length, which, however, does not represent the original length of the fulgurite, which must probably have been some, possibly many, feet longer.[1]

Although the structures described in this paper present no new features, yet the interpretation put upon them may serve to confirm the views already advanced by Mr. Merrill and Professor Bayley. So far, however, as I am aware, no attempt has hitherto been made to account for the irregularly crumpled sheets of vitrified sand which constitute, in all probability, the extremities of fulgurites of the sand-tube type.

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[1] A fulgurite from this locality measured 40 feet in length—G. D. Gibb, *Trans. Geol. Soc.*, Vol. II. 528. Another from Macclesfield extended to a depth of 22 feet—A. H. Green, *Geol. Surv. Memoir on Sheets* 81 N.W. *and* 81 S.W. p. 76.