Sand Fulgurites with Enclosed Lechatelierite from Riverside County, California

by Austin F. Rogers
Stanford University

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by AUSTIN F. ROGERS
STANFORD UNIVERSITY

ABSTRACT

Sand fulgurites from the vicinity of Indio, Riverside County, California, produced by the incomplete fusion of sand derived from granodiorite, contain fragments of lechatelierite formed by the more or less complete melting of some of the quartz grains. Some cristobalite is also present. The biotite grains have been completely fused to a dark-brown glass: the feldspars were, for the most part, melted to form a pale, almost colorless, glass.

Introduction

Among inanimate natural-history objects, few are more striking than fulgurites (L. *fulgur*, "lightning"), the curious glassy tubes formed by the fusion of sand by lightning. The term "fulgurite" has been extended to cover superficial coatings of glass produced from consolidated rock by the same agency, these being designated "rock fulgurites," to distinguish them from the more usual "sand fulgurites." A good general account of fulgurites with an extended bibliography will be found in the excellent paper of W. Fischer.[1]

In this country, sand fulgurites have been described from Massachusetts by E. Hitchcock,[2] from North Carolina by A. R. Leeds[3] and by J. J. Petty,[4] from South Carolina by Merrill[6] and Petty,[4] from Florida by J. S. Diller,[5] and G. P. Merrill,[6] from Illinois by Merrill,[6] from Maine by W. S. Bayley,[7] from Wisconsin by W. D. Shipton,[8] from New Jersey by W. L. Barrows[9] and by W. M. Myers and A. B. Peck,[10] and from Michigan by A. F. Rogers.[11]

Megascopic Description

For the fulgurites described in this paper I am indebted to Mr. W. Scott Lewis, mineral collector and dealer of Hollywood, California. They were obtained from a prospector, who would

[1] "Blitzröhren aus den miocänen Glassanden von Guteborn bei Ruhland, Ober Lausitz," Neues Jahrb. f. Min., Geol. u. Pal., Beil. Bd. Vol. LVI, A (1928), pp. 92-98.
[2] "Fulgurites or Lightning Tubes," Amer. Jour. Sci., 2d ser., Vol. XXXI (I86I), p. 302.
[3] "On a Fulgurite," Proc. Acad. Nat. Sci. Phila., 1874, p. I45.
[4] "The Origin and Occurrence of Fulgurites in the Atlantic Coastal Plain," Amer. Jour. Sci., 5th ser., Vol. XXXI (I936), pp. I88—20I.
[5] "Fulgurite from Mount Thielson, Oregon," Amer. Jour. Sci., 3d ser., Vol. XXVIII (I884), pp. 252-53.
[6] "On Fulgurites," Proc. U.S. Nat. Mus., Vol. IX (I886), pp. 83—9I.
[7] "A Fulgurite from Waterville, Maine," Amer. Jour. Sci., 3d ser., Vol. XLIII (1892), pp. 327 28.
[8] "A Note on Fulgurites from Sparta, Wisconsin," Proc. Iowa Acad. Sci., Vol. XXIII (I9I6), p.
[9] "A Fulgurite from the Raritan Sands of New Jersey, with an Historical Sketch and Bibliography of Fulgurites in General," School of Mines [Columbia] Quarterly, Vol. XXXI (I909—IO), pp. 294—3I9.
[10] "A Fulgurite from South Amboy, New Jersey," Amer. Min., Vol. X (1925), pp. 152-55.
[11] "A Review of the Amorphous Minerals," Jour. Geol., Vol. XXV (I9I7), p. 526.

Figure 1. — Sand fulgurite from the region around Indio, Riverside County, California. Natural size

not divulge the exact locality but stated that they were from the region around Indio in Riverside County. The specimens are more or less hollow, somewhat branching, irregular, cylindrical objects of medium-gray color, varying in length from 6 cm. to a maximum of about 30 cm. and in diameter from 1/2 cm. to about 2 cm. Figure 1. is a photograph of a typical specimen; the cross sections are circular or nearly so, as shown in Figure 2. They have a superficial resemblance to the roots of certain plants. On the exterior, colorless and white to dark brown sand grains are visible. A broken surface shows sand grains imbedded in a gray vitreous glass, and more or less spherical cavities lined with a lustrous glass. A rough determination of the specific gravity of an inch-size piece of fulgurite gave 2.01, which is obviously low because of cavities.

The sand grains are angular to subangular, with a size variation ranging from 15 microns (μ) up to about 75 μ, but are mostly between 30 and 50 μ. Among the identified minerals of the sand are quartz, orthoclase, microcline, plagioclase, biotite, magnetite, a little zircon, and rock fragments (a grained igneous rock). The sand, which shows little sign of any sorting, was apparently derived from a granodiorite or similar rock.

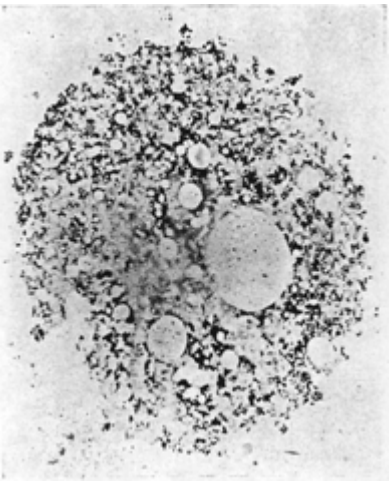

Figure 2. — Cross section of sand fulgurite showing general features. X 8.

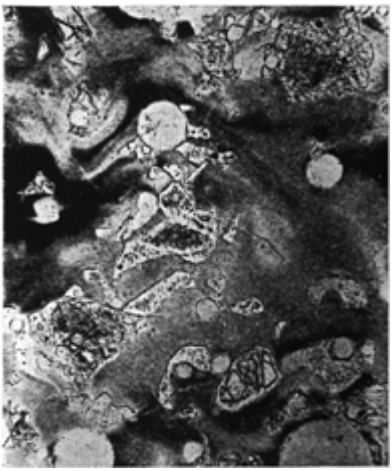

Figure 3. — Thin slide of sand fulgurite showing groundmass of dark to pale brown glass with circular sections of spherical vesicles and imbedded sand grains, which are more or less fused to silica glass. X 50.

I was familiar with sand fulgurites, produced from quartzose sand, which consist largely of lechatelierite[12] or silica glass. On noting the relatively large amount of ferromagnesian minerals (biotite) I concluded that there would not be any lechatelierite in thin sections of the Riverside County fulgurites, but I was agreeably surprised to discover that many quartz grains had been wholly or in part converted into lechatelierite.

Figure 2, a low-power photograph of a section of one of the fulgurites normal to the length, gives a general idea of its structure. The nearly circular sections of the vesicles point to the absence of any appreciable flowage. The writer[13] in recent years has considered lechatelierite to be a mineraloid rather than a mineral proper. The useful term "mineraloid" was

[12] "Lechatelierite" is the name given to the silica glass of fulgurites, meteor craters, and inclusions of volcanic rocks by Lacroix ("La silice fondue considérée comme minéral [lechateliérite]," Bull. Soc. fran. de min., Vol. XXXVIII [I9I5], pp. I82-86).
[13] Rogers, A. F., Introduction to The Study of Minerals (3d ed.; New York: McGraw-Hill, I937), p.324.

proposed by J. Niedzwiedzki[14] for amorphous mineral-like substances.

Microscopic Description

General relations. — Figure 3 is a photomicrograph of a thin section (SMC 9) of one of the fulgurites. The dark areas represent almost opaque glass, produced by the fusion of biotite, which has a melting point of 1,050° C. The ground mass, or main portion, of the section is a pale-brown to almost colorless glass, produced largely by the melting of the feldspars. The index of refraction of the glass varies from about 1.5I0 up to about 1.550; the variation is evidently dependent upon the iron content. Some of the sand grains are intact; but most of them are more or less shattered, and on the borders many are melted.

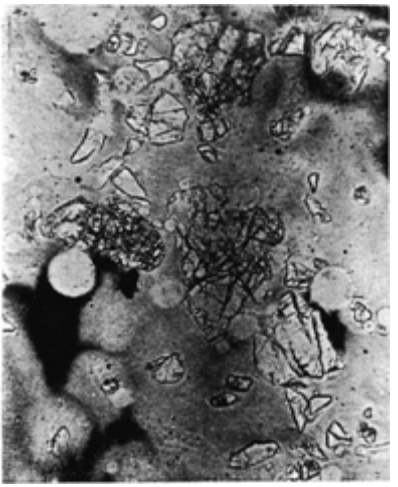

Figure 4. — Thin slide of sand fulgurite (an area different from that of Fig. 33, showing shattered quartz grains penetrated by silica glass. X 50.

Figure 5. — The same area as that shown in Fig. 4, but taken with crossed Nicols. X 43.

Figure 4 shows another area in the same section. The angular unsorted quartz grains have been shattered, and in

[14] "Zur mineralogischen Terminologie," Centralbl. f. Min. Geol., u. Pal., I909, pp.66I—63.

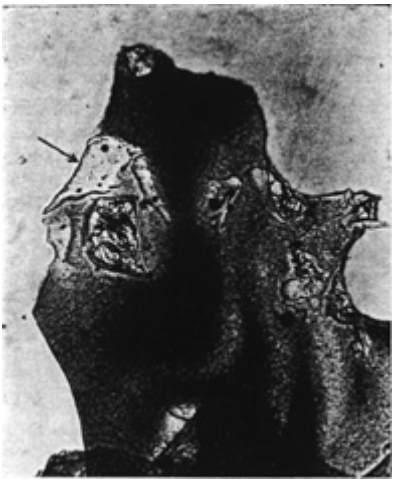

Figure 6. — Fragmentary thin slide of one of the sand fulgurites temporarily mounted in a liquid with n = I.480, showing on the left margin lechatelierite (n = I.457). The microscope tube is raised to show the Becke line. X 200.

Figure 7. — Enlarged view of area at the center of Fig. 3, showing quartz grains altered in part to lechatelierite. X 123.

the larger grains silica glass has penetrated along the cracks. Figure 5 is the same area but taken between crossed Nicols. Here the silica glass appears isotropic.

Lechatelierite. — The first thin section made of the Riverside County fulgurite is shown in Figure 6. This small section was made to identify the isotropic fragments observed. The colorless grain marked with an arrow proved to have a refractive index of 1.457 ± 0.003. With a Wratten E22 screen being used in lieu of sodium light, this determination was made upon the unmounted section mentioned by employing successive immersion liquids after cleaning the section with xylol and drying each time. This is undoubtedly lechatelierite, or silica glass, produced by the fusion of a sand grain of quartz. This is the first noted occurrence of lechatelierite in the state of California.

The central part of the photomicrograph of Figure 3 is shown in enlargement in Figure 7. Some of the quartz

grains have been completely melted to form lechatelierite. The equant central grain and the large crescent-shaped one near the center were partially melted but contain relict quartz, as shown by the difference in relief of the interior.

Cristobalite. — Figure 8, also made from section SMC9, shows near the center an equant grain of quartz which has been converted in part into cristobalite. Around the border of the grain the curved structure so characteristic of cristobalite is apparent. It also shows very weak nonuniform birefringence with a red-1-order plate. This central grain contains relict quartz, which does not show well in Figure 8 but is brought out in the photomicrograph (Fig. 9) of the same area taken with crossed Nicols. In the thin sections it is often difficult to distinguish cristobalite from the lechatelierite.

FIG. 8. — The large grain near the center has been altered on the exterior to cristobalite. The other grains are altered in part to lechatelierite. X IOO.

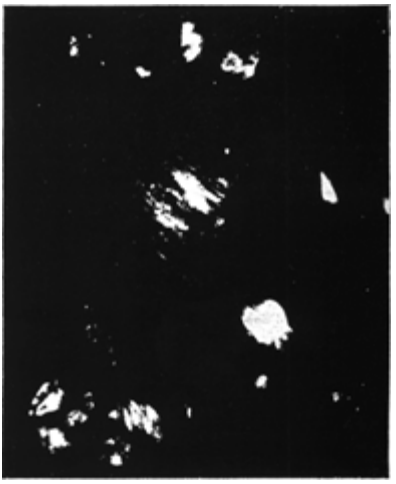

FIG. 9. — The same as Fig. 8, but taken with crossed Nicols to show relict grains of quartz. X 92.

Nothing resembling tridymite was found in any of the sections.

Newly formed product. — In several of the thin sections small amounts of minute acicular crystals were observed. Some of these resemble feldspars, but they could not be identified with any degree of certainty.

Discussion

The incomplete fusion of the sand derived from granodiorite may be explained by the extreme rapidity of a lightning discharge. According to my colleague, Professor Joseph S. Carroll, director of the Ryan High-Voltage Laboratory, lightning discharges take place in less than 100 microseconds (a microsecond being one-millionth of a second).

The temperature reached in the partial melting of the sand was probably in the neighborhood of 1,800° C. According to R. B. Sosman[15] quartz may be melted at 1,400° C. if sufficient time is given, but the rapid melting requires a temperature of about 1,800° C. Variation in temperature is evidently due to differences in electrical-resistance from point to point.

The examination of the thin sections gives evidence of some diffusion in the glass of the goundmass but little evidence of any flowage. The circular sections of the vesicles are in marked contrast to the elliptical vesicles of volcanic rocks.

[15] "Silica as a Refractory in the Steel Industry," advanced paper read before the American Iron and Steel Institute, New York, May 24, 1929 (p. 24).

THE EVENT

PETRIFIED LIGHTNING FROM CENTRAL FLORIDA

A PROJECT BY ALLAN MCCOLLUM

CONTEMPORARY ART MUSEUM
UNIVERSITY OF SOUTH FLORIDA

MUSEUM OF SCIENCE AND INDUSTRY
TAMPA, FLORIDA