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ARTIFICIAL FULGURITE
BY UTILIZING ROCKET
TRIGGERED LIGHTNING*

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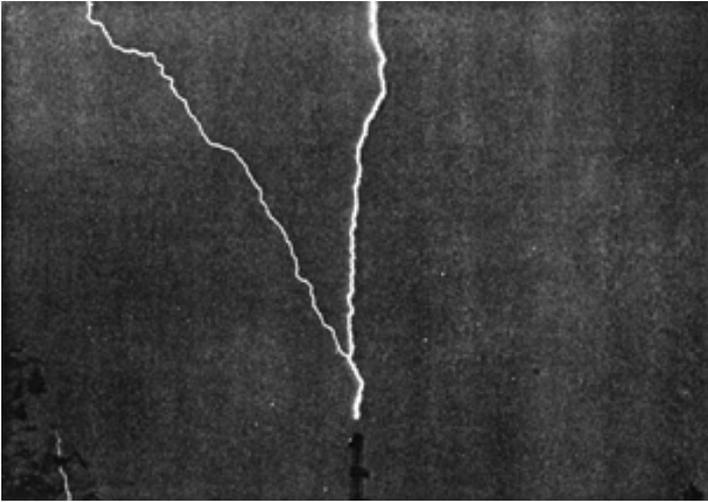
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ABSTRACT

Fulgurite is a kind of mineral produced along the passage of lightning current in the sand, rock, etc. and is characterized by some natural quartz glasses. The theoretical production mechanism of fulgurite has not yet been clarified because the lightning is an accidental phenomenon. In the present study, the authors succeeded in the artificial production of the fulgurite by using



prepared materials in a container, passing through it lightning currents triggered by rocket. It is believed that this is the first success in the artificial production of fulgurite in the world.

INTRODUCTION

Fulgurite is characterized by lechatelierites and cristobalites, kinds of natural quartz glass, produced by lightning striking in deserts, seashore, mountain tops, and so forth. The fulgurite has been known from the old time in many countries, and in fact, a relatively large amount of fulgurites are distributed. In Japan, the fulgurite has been generally unknown, probably because the quantity of fulgurite existing in Japan is very small. The production mechanism of fulgurite has not been theoretically established, because thunderbolt itself is very accidental.

As a result of lightning-stroke to sand, rock, etc., lechatelierites and cristobalites, kinds of quarts, are produced. Depending on the types of such substances, problems to be revealed have been presented, such as remnant magnetism, the deposition of free silicon, production of crystallite due to the devitrification, etc. and more over, the conversion to a substance having a different refractive index, and so forth.

So far, there has been neither report on the production mechanism of fulgurite, nor artificial production of it. In the present study, first, the shapes and properties of fulgurites were investigated. Based on the result, reproduction of fulgurite was made utilizing the natural lightning which was artificially triggered by rocket.

ON FULGURITE

The name “Fulgurite” was given after Latin “Fulgar (thunderbolt)” by Arago Dominique Francis Jean [1]. In England, the Fulgurite is called a lightning tube, also.

In Japan, it is called Denkanseki, Raikanseki, Raiseki, Raito, or Sendengan [2].

The fulgurite is categorized as sand fulgurite and rock fulgurite. Sand fulgurite is a kind of fulgurite and take the form of a hollow cylinder with a diameter of 0.5 - 1.5 cm. The inner walls are smooth, and the cross-sections are ellipsoidal rather than circular. Some sand fulgurites take a zigzag shape and are tri-, tetra- or pentagonal.

Also, certain sand fulgurites are found to have developed, taking the shape of the streamers passing through the sand, and the others have been closed or bent, taking a spherical, block, or bag-shape, caused by gravels disturbing the streamers from

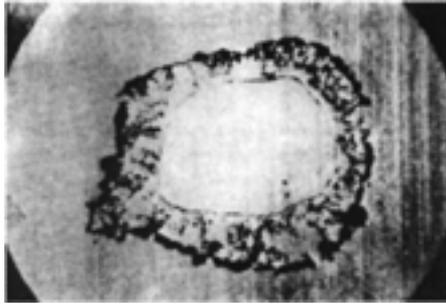


Figure 1: Cross-section of Fulgurite
Magnification: x10

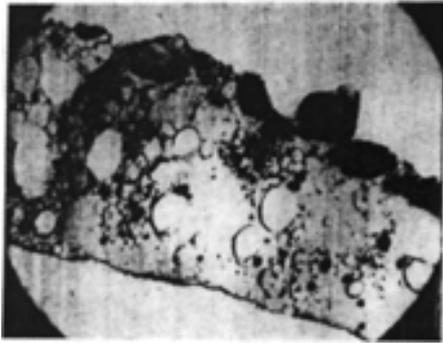


Figure 2: Partially enlarged view of Fig. 1
Magnification: x50

propagating on the way. As shown in the cross-sections of the cylindrical fulgurites in Figs. 1[3] and 2[3], the inner walls are ellipsoidal and glassy, and have a silver or milk-white

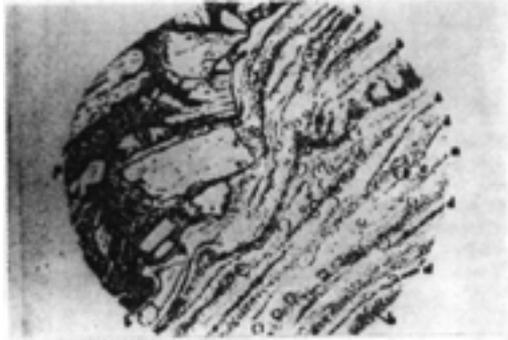


Figure 3: Microscopic photograph of rock fulgurite
Magnification: x50

color. This is probably because the fulgurites have become opaque with the devitrification of the quartz. That is, when the fused glass is cooled or heated, crystals are deposited in the glass. In this case, the fulgurite have been converted to lechatelierites and cristobalites which are natural quartz glasses.

The energy of the lightning stroke is enormous, and the temperature of a single lightning is estimated to be several 10,000°. Accordingly, it is considered that in the presence of H₂, C,

or CO, SiO₂ is easily reduced in the high temperature and is dispersed in its atomic state. Silicon is fused at 1,420 degree and boiled at 2,355 degree at 1 atm.

Also, it was observed that the crystallization of glass were promoted by passing various kinds of bubbles through the glass, influenced with the absorbed steam.

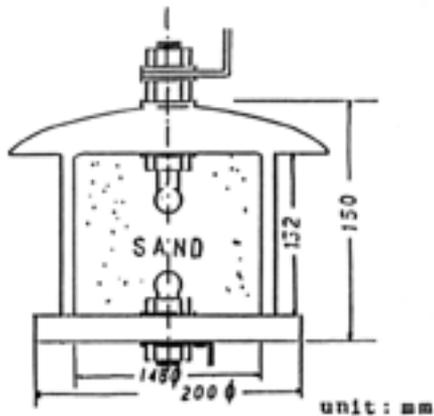


Figure 4: Container for production

The sand fulgurites have been found in the Michigan Lake shores, the Atlantic coast, Poland, and the Sahara desert[3]. In Japan, the sand fulgurite having such a large size as those found in the above district have not been observed. However, only one case was reported [4], in which the lightning was struck into straw bundles in Nemuro, Hokkaido District, and the soils under the straw bundles became glassy.

Grain (μm)	%
+2.000	14.9
2.000 - 1.000	27.5
1.000 - 500	25.3
500 - 250	19.2
250 - 125	8.5
125 - 88	2.1
88 -	1.4
less	1.1

Table 1: Grain size distribution

Figure 3[3] shows the microscopic photograph of Wyoming rock fulgurites. The fulgurite is shown in the right half of the photo, left half being the host rock. Some more explanation is made in a companion paper [5].

AREA AND ARRANGEMENT FOR EXPERIMENT

The experiment in the present study was made by using the #30 pylon of the transmission line not in service owned by The Hokuriku Electric Power Co., Inc. This area is located at Okushishiku Heights in Ishikawa Prefecture and 1,000 m in altitude. Many power apparatus were subjected to experiments by utilizing artificially triggered lightning during the winter season in this area [6].

For the test, a container shown in Fig. 4 was filled up by the raw material for the production of artificial fulgurite. The top terminal of this container was connected to the lead wire

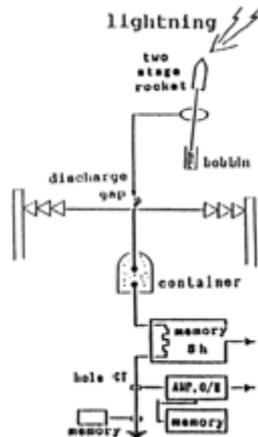


Figure 5: Circuit diagram for the experiment

of the rocket, and the bottom terminal of it is grounded through measuring instruments as shown Fig. 5.

The raw material used was "Tempaku River sand," obtained at Tempaku Riverside in Nagoya City. The grain size is shown in Table 1, lying in a range of 250 - 2000 mesh. This is a typical river sand whose main mineral components were quartz, feldspar and a little biotite.

The container was subjected to the current passage of two triggered lightning shots. The magnitudes of the current were 12 and 17 kA, both of negative polarity. Figure 6 (a)(b) shows the photos of the relevant lightning current wave forms. After the two shots, the container was opened, and artificial fulgurite was found produced.

ANALYSIS OF ARTIFICIAL FULGURITE

The artificial fulgurite thus produced had a cylindrical form, whose appearance is as shown in Fig. 7. Figure 8 shows the mi-

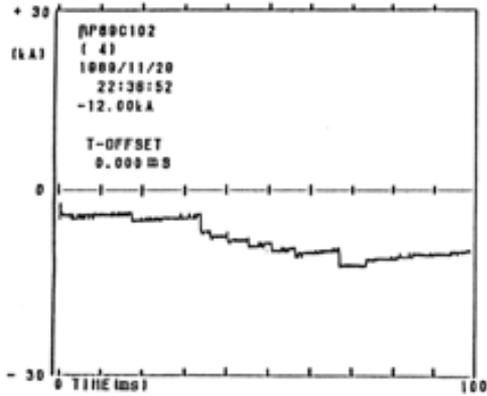


Figure 6: (a) Lightning Current Wave Form (a)

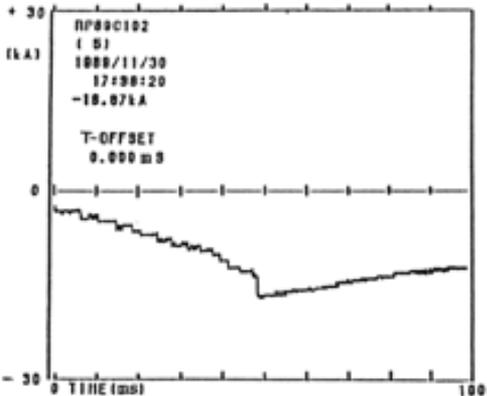


Figure 6: (b) Lightning Current Wave Form (b)

crograph of the cross-section of the fulgurite. This is very similar to Fig. 1. Namely, the cross-section of the fulgurite is substantially concentric; in the concentric cylinders, the next outer part is done of striking raw materials, and the outermost part is the remained raw materials. These materials are present in the circular range with a radius of several cm and sometimes with a diameter of 15-16 cm. Such constitutions cannot be produced by any other means.

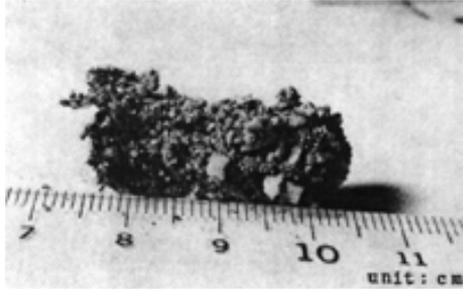


Figure 7: Fulgurite made by rocket-triggered lightning

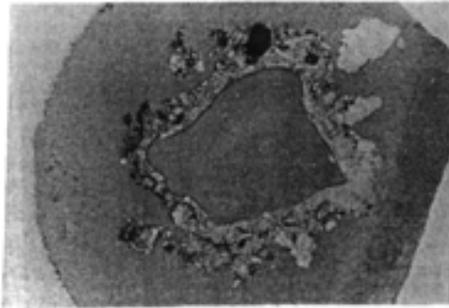


Figure 8: Fulgurite made by rocket-triggered lightning, cross-sectional view
Magnification: x 7

The followings are main points of the detailed analysis:

(1) All the reflex index of quartz decreases at the X-ray analysis and the environs of feldspar change amorphous glass in the microscope observation.

(2) The fulgurite was 3, 1 and 0.6 cm in length, outer diameter and inner diameter, respectively. The center part of fulgurite was hollow through which the thunder streamer passed and the inner wall was amorphous glass cylinder. The cylinder was 2 - 200 micrometer in thickness.

(3) The amorphous glass joints raw materials which remained at periphery of the fulgurite.

(4) The amorphous glasses are lechatelierite and cristobalite, which are characteristic minerals of the fulgurite.

CONCLUSIONS

(1) Fulgurite was produced by the artificially triggered natural lightning.

(2) Lechatelierite and cristobalite are found produced. They are very useful important materials in the manufacturing industry since they exist rarely in natural mineral ores in Japan.

(3) As the thunderbolt is natural phenomena and even contingency, it is very difficult to investigate the production mechanism of the fulgurite. There were many fulgurite fossils discovered at various districts in the world. But it is a mere conjecture that the fulgurites were made by the thunderbolt. In the present study, the production mechanism by the rocket triggered lightning.

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THE EVENT

PETRIFIED LIGHTNING FROM CENTRAL FLORIDA

A PROJECT BY ALLAN MCCOLLUM

CONTEMPORARY ART MUSEUM
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MUSEUM OF SCIENCE AND INDUSTRY
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