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A FULGURITE FROM KARNAK, WESTERN VICTORIA.

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ABSTRACT.

This paper records the discovery of a fulgurite approximately 5 feet long in a sandhill at Karnak, Western Victoria. It has been formed by a lightning discharge penetrating the sandhill and melting the quartz sand along its path. The fulgurite is tubular in form, and is composed essentially of lechatelierite (silica glass) and partly fused quartz grains. Its central cavity is considered to be due to rapidly-developed outward pressure from the expansion of heated gases (steam and air) along the path of the lightning discharge. Probable causes and modes of formation of various other characters of the fulgurite are discussed. New records of Victorian fulgurites are listed from Goroke, Kiata and Glenthompson.

INTRODUCTION.

In October 1959 an unusual specimen was submitted to the Museum for identification. The specimen, found at Karnak in Western Victoria, proved to be a fulgurite fragment. As few fulgurites had been recorded from Victoria, only two fragments being then in the Museum Collection, further search in the vicinity was encouraged. This search resulted in the finding of the fulgurite now described. It is similar in nature to what are called "saud-tube" fulgurites by Fenner (1949). It has been formed by the melting of quartz sand by lightning, and is tubular in form. The fulgurite is the longest so far discovered in Victoria.

OCCURRENCE.

The fulgurite (see Plate 1) was found by Mr. H. A. Keys in a sandhill on the property of Mr. J. F. Armstrong of Karnak, 9 miles south of Goroke, Western Victoria. This is flat, semi-desert country just south of the area known as the Little Desert. The fulgurite came from allotment 18, Parish of Karnak, County of Lowan.



FIG. 1.—Map showing Victorian fulgurite localities.

Following the discovery of a small fragment lying on the surface of the sandhill, a number of similar pieces was found scattered about nearby. Several months later, at the same locality, a piece of fulgurite was seen projecting a little above the sand surface. Arnstroug and Keys dug at this point and, on finding that the fulgurite extended vertically downwards, they excavated to a depth of 6 feet and extracted the entire fulgurite from the sand. It proved to be brittle and, in spite of great care, broke into segments up to 3 inches in length during the excavation and removal. Each piece was systematically kept, and the fulgurite has been mounted to exhibit its original form. Photographs (see Plate 2) were taken at various stages of excavation of the fulgurite, which occurred practically vertical in the sand.

DESCRIPTION.

The Karnak fulgurite has a length of just over 5 ft. 1 in. It diminishes in width vertically from a maximum diameter of 20 mm. at the top to 3 mm. at the base.

At 2 ft. 5 in. from the top, a branch emerges downward at an angle of 20 degrees with the vertical. This branch gradually diminishes in diameter from a maximum of 6 mm. at the top to 3 mm. at the base.

At a distance of 4 ft. 7½ in. from the top the fulgurite bifurcates, the length of each forked branch being 5½ inches.

The exterior of the fulgurite is very pale fawnish grey in colour and has a rough surface. There are three or four sub-parallel, discontinuous longitudinal ridges and many small protuberances (papillae and spikes) on this outer surface. It is encrusted with partly fused and adherent unfused sand grains.

The wall of the fulgurite tube averages about 1 mm. in thickness, ranging from 0.5 mm. to 2 mm. The internal opening (lumen) is lined by smoothed and glazed silica glass (lechatelierite) containing numerous gas vesicles. Some of these cavities can clearly be seen with a hand lens, and thin sections of the fulgurite show that as well as being abundant the gas vesicles are of various sizes and shapes. In colour the lechatelierite is smoky-grey or white to the naked eye, while under the microscope much of it appears brownish. The dark colour is evidently due to impurities such as iron oxides. Flow

lines are quite conspicuous in parts of the glass, and are frequently parallel to the length of the fulgurite. Passing outwards towards the exterior, partly fused sand grains become common; they are almost entirely quartz grains.

The lumen is subcircular in cross section. It is widest at the top of the fulgurite, where the maximum diameter is 7 mm., and it decreases downward to 1 mm. at the bottom. This tubular cavity was found to be almost completely filled with sand.

The specific gravity of a small piece of the fulgurite, ground to a powder which was boiled in distilled water to expel all air before drying and weighing, was found to be 2.18.

Since fulgurite fragments were found scattered around the top of the Karnak fulgurite on the surface of the sandhill, the original length was apparently greater than that stated above. At the locality the sandhills are not grassed, and the surface sand is blown about particularly during periods of dry, windy weather. The number of fragments on the surface suggests that the effects of wind erosion have caused a reduction of at least 1 foot in the length of the fulgurite.

In external shape the Karnak fulgurite closely resembles a fulgurite from Moreton Island, Queensland, described by Couah, (1947, p. 20).

COMPOSITION.

Microscopic examination has shown that the Karnak fulgurite is composed essentially of lechatelierite (silica glass) and partly fused quartz grains—i.e., it is composed essentially of silica.

Chemical analyses of "sand-tube" fulgurites from different parts of the world show that they are of practically the same composition as that of the sands in which they were formed. A mechanical analysis of the sandy material surrounding the Karnak fulgurite shows that it is made up of:—

Sand size particles—92.15 per cent.

Silt size particles—6.19 per cent.

Clay size particles—1.66 per cent.

Under the microscope this surrounding sand is seen to be composed almost entirely of quartz. Other minerals, including limonite, feldspar, magnetite, ilmenite, leucosene, tourmaline, zircon, rutile and mica, are very scarce. The quartz grains are not greatly iron-stained.

A mechanical analysis of the sandy material from inside the fulgurite tube showed that it is made up of:—

Sand size particles—92·13 per cent.

Silt size particles—6·29 per cent.

Clay size particles—1·58 per cent.

The mechanical composition is thus almost identical with that of the sandy material surrounding the fulgurite. Microscopic examination has shown that the mineralogical composition also is almost identical with that of the sand surrounding the fulgurite.

Chemical analyses of " sand-tube " fulgurites (Fenner, 1949, p. 134) show a range in silica content from 88·46 per cent. to 96·44 per cent. It has generally been found that the fulgurite is more siliceous than the surrounding sand.

FORMATION.

Enquiry has indicated that violent electrical storms are not infrequent in the Karnak—Goroke area of the Western Wimmera and also in the adjoining Mallee district of Victoria. There are many sandhills in both of these districts.

To form the Karnak fulgurite a lightning discharge penetrated the ground to a depth of more than 5 feet, forking twice and melting the quartz sand along its path. A very high temperature must have existed, since the melting point of quartz is over 1,700 degrees Centigrade—although with some materials with fluxing effects present the quartz would melt at a lower temperature.

The internal opening (Innen) is most probably due to rapidly-developed outward pressure from the expansion of heated gases (steam and air) along the path of the discharge. Excavation work to extract the fulgurite from the sandhill showed that the sand became damp at a depth of 3 inches below the surface, and that water was present at a depth of 5 ft. 6 in. Enquiry indicates that the sand remains damp within a few inches of the surface throughout the year, although the water table falls during the summer months. The terrific heat of a lightning discharge in damp sand would produce a large amount of steam almost instantaneously, as well as melting the sand grains. Microscopic examination shows clear evidence of the flow movements that occurred in the once viscous and frothy siliceous mass. Cooling of the melted mass of silica was rapid, the outer

part solidifying first. Pressure mainly from the rapid expansion of the steam would force hot, plastic silica outward, apparently producing a tubular space up which the gas rushed to escape at the top. Since the cooling was too rapid for crystallization, the fulgurite solidified as a mass of vesicular silica glass with a tubular form.

The glazing on the surface of the lumen has apparently been caused by the rush of gas upwards through the tube.

With reference to the semi-fused and unfused sand grains, it would seem that they were embedded in the rapidly cooling mass by the external pressure of the surrounding sand.

The water table appears to have been a factor in determining the downward limit of the fulgurite; and the fulgurite's shape is no doubt partly due to differential resistance to passage of the lightning discharge, resulting from variations in moisture content, compaction, &c. of the sand.

Unequal contraction of the fulgurite glass on cooling would produce fine cracks in it. Subsequent weathering would enlarge some of these cracks and, from settling of the sand in the sandhill, there would probably be further fracturing of the thin-walled fulgurite. Some material has probably entered the central cavity through such cracks, although most of the sand inside the fulgurite tube is believed to have entered from the top. Since the fulgurite would be left open at the top on solidification, sandy material might have entered soon afterwards.

With reference to the formation of fulgurites, Simpson (1931, p. 146) has recorded that at West Popanyiming in Western Australia a violent flash of lightning was seen to strike some sandy ground and "thereafter smoke or steam was observed rising from the ground where it was struck". He records that on quick investigation the ground was found to be blackened and still hot over an area of about 50 square inches, and digging revealed a "sand-tube" fulgurite approximately 3 feet long.

Fulgurites considerably longer than the one here described have been found in various parts of the world. The force of the lightning stroke, the thickness of sand, and the resistance to the passage of the electrical discharge in the ground are the controlling factors which determine the length of "sand-tube" fulgurites. In considering the formation of fulgurites it is significant to note that, according to Professor L. B. Loeb (1949, p. 22), a temperature of 30,000 degrees Centigrade may be reached in a lightning flash.

VICTORIAN FULGURITE LOCALITIES.

In Victoria, fulgurite fragments have been recorded by Fenner (1949, p. 133) from Bronzewing, near Ouyen, in the Mallee district. Baker (1959, p. 217) has also recorded them from several places in the Mallee district, viz., at Yarrara, Red Cliffs, Tempy and south of Cowangie.

As well as at Karnak, fulgurites have recently been discovered at Goroke, Kiata and Glenthompson in Western Victoria. At these localities they were found mainly as small fragments lying scattered about on the surface of sandhills. However, excavation in a sandhill near Goroke resulted in the extraction of a fulgurite which persisted downwards for 3 feet. The specimens from these localities are now in the Collection of the National Museum of Victoria. They are similar in nature to the Karnak fulgurite.

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PLATE 1.

The Karnak fulgurite mounted for display purposes.



Fig. 1. Commencement of fulgurite excavation at Karnak, Western Victoria.



Fig. 2. A later stage of the excavation. Note piece of fulgurite in man's hand.

PLATE 2.