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Copper in Rock Tubes
A Desert Mystery

by Robert W. Webb
University of California, Santa Barbara

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The name "Robert W. Webb" is a familiar one to mineralogists — both professional and amateur. Elsewhere in this magazine there is an announcement of Dr. Webb's latest contribution to "the literature"— a new edition of time-honored Minerals of California, revised by Dr. Joseph Murdoch and Dr. Webb, and reissued as Bulletin 189 of this Division. In calling Minerals of California "a contribution to the literature", we greatly underestimate its impact; it would be more correct to say "a contribution to the daily lives of thousands of Californians". The following article is a desert mystery story, told by a well-known mineral sleuth. We are sure our readers will find this "who-and-what-done-it" as absorbing as we did .   ...Edit.

Lightning strikes the earth millions of times each year. However, only under conditions still but partially understood does the lightning induce changes in surface rocks. Among the most curious and best known of these changes are the glass tubes that form along lake shores primarily in unconsolidated sands and dune areas. They have been subjects of comment by the curious since primitive man came to know and fear lightning. These tubes, called fulgurites, were described at least as early as 1711, and it is probable that in very early times the role of lightning was in fact recognized, since ". . . Cicero used the expression 'condere fulmina' (to dig up thunder bolts),"[1] and the class of soothsayers known as 'fulgiatores' carried out ceremonies on the spot where lightning struck. When solid rock has been hit, for instance, on mountain peaks and ridges above timber line, shatter cracks, spalled rocks, and some spatter patches and droplets of glass have been found (see bibliography). But fulgurite tubes are rare in bedrock, even though lightning can be accompanied by temperatures as great as 2500°C.

Recently, lightning tubes have been found in undecomposed quartz diorite, a plutonic igneous rock. These tubes were collected by Jim Robbins, who holds a mining claim on the property which is in Riverside County, California. Mr. Robbins, Keller Q. Heuring, and I visited the property to inspect some fulgurites in place and some hundreds of pounds of material collected from the site. The fulgurites still in place are as large as 2 inches in diameter, and as much as 15 inches in length.

Mr. Robbins reports that, before excavation at the property, there were many tubes longer than the measurements cited. There are three such tubes still in place on the claim, but it appears that there were as least seven and maybe more large tubes in the 20-foot circular area in which the tubes were distributed. According to Mr. Robbins, each tube, at depths up to 12 1/2 feet, divided into larger tubular and rootlike bases. The tubes that remain in place seem to become smaller, however, a few inches below the "root" system. Down 15 inches below the "roots" of the tubes that remain in place, evidence of the melt-

[1]Vokes, H. E., "When the earth is electrocuted": Natural History, vol. 44, pp. 158-59, 1939.

ing and flow of glass and oxidation coatings are found on selvages and slickensides. The rock is sheared and broken by small joints and faults, as the locality lies in shear zones parallel to and near the fault system of the eastern Imperial trench. Each tube is hollow with glass selvage in the upper 6 or 7 inches. The melt from the upper parts of tubes flowed into lower segments and congealed, thus filling the fulgurites completely with glass in the base of the master tube and in the root system. It is apparent that the temperature in the glass at the base was maintained or was sufficiently high to permit flowage for several inches downward and outward.

The unfused margins of the tubes have highly fluorescent feldspar crystals and grains of the rock; the feldspar in the country rock and in the upper parts of the fulgurite contacts is nonfluorescent. This seems to suggest that temperature has been sufficiently high to "crackle" some of the feldspar, leaving vacancies or holes in the feldspar crystal lattice. The stress is thereby reflected in fluorescence.

Many of the fulgurite tubes are small in diameter. Many more gas pockets (vesicles) appear in the smaller ones than in those of larger dimension. The vesicles of many of the fulgurites are oriented crudely, and such flow structure attests to the mobility of the glass as well as to the contact effects on the margins of the tubes. Occasionally, obsidian from tubes has flowed over pebbles of the alluvial apron adjacent to the base of the small bedrock hillslope where the fulgurites are concentrated.

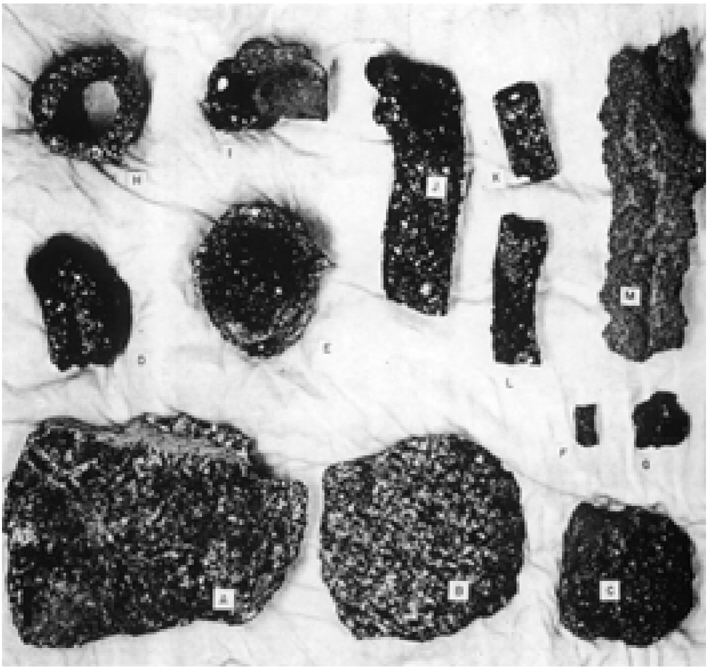
Of particular interest is the metallic copper that fills the vesicles indiscriminately. The aggregate amount of copper, though difficult to estimate, appears to be as much as 40 pounds. It was the metallic copper that first alerted Mr. Robbins to the special nature of the materials. When I visited the property, all the copper had been collected, but several specimens of the vesicular rock carried blebs and globs of copper in place in the vesicles. Generally, the blebs were 4 inches or less in length and were connected through small vesicular chambers into copper strings, much the way that crystals of copper are sometimes arranged in chains, both in nature and in furnace products.

Examination of the surrounding region established that the rock materials are massive and uniform. In this section the surface rock is the dioritic member of the Chuckwalla Complex, named by T. W. Dibblee in 1954. Of the few inclusions that are present, none gives any signs of copper. Occasional selvages of some of the joints in the vicinity have the greenish color of malachite or chrysocolla, but not in sufficient quantity to permit collection of a good specimen. As a result, the source of the copper is obscure. The locality is more than a mile from any traveled road, and a quarter of a mile from any road at all. The closest power line is nearly 2 miles away but herein may lie an explanation.

Increasingly, in recent years, copper has been stolen from the numerous transmission lines that crisscross the Mojave and Imperial desert regions. The thefts have become so common that some of the lines are patrolled by plane. The Los Angeles Department of Water and Power published a circular entitled *Stolen Copper*, urging the cooperation of the public in apprehending thieves whose activities on the Boulder-Los Angeles power lines alone caused losses in 1965 in excess of $25,000. Thefts include not only copper spark-gaps, but also quarter inch-diameter copper ground wire.

In the rubble from excavation of the vesiculated rock, a single specimen showing the remains of one strand of wire, 2 inches in length and three-eighths of an inch in diameter was recovered. Though the wire does not match the type used on the Los Angeles transmission lines, it is far too large gauge to be found on other than a high tension transmission system. It seems probable that stolen copper wire was scuttled by someone who expected to return for the booty, or who thought he was about to be apprehended. No other explanation seems reasonable, especially since all transmission lines appear to have suffered from thefts such as those experienced on the Boulder-Los Angeles line.

In the locality under discussion, the distance from a road remains a puzzling factor. Some evidence suggests though, that the copper had been on the ground for some time. Therefore it may have been thrown down at a time when an unimproved



Fulgurite and associated rocks from copper-bearing fulgurite locality in Riverside County. A. Glass rivulets on joint selvage of quartz diorite. From lower part of "root" system of fulgurite swarm. B. Fresh quartz diorite rock of Chuckwalla Complex. C. Droplets of glass on country rock, probably spatters from boiling glass. D. Glass center of filled fulgurite. E. Glass-filled base of fulgurite tube. Actual size is 21/2" x 2" in cross section. Specks of copper appear in polished cross-section of this specimen. F. Small fulgurite tube, 5/8" long, l/4" diameter, 3/l6" hole. G. Glass tube in country rock with oxidized selvage, 3/4" long. H. Fulgurite. Typical cross-section of upper part of fulgurite tube; hole is l l/4" in diameter. I. Hollow tube of glass (and rubble) which flowed around a pebble of quartz schist from gravels that lap onto bedrock. J. Tube 1 1/4" diameter, 5" length. K. Tube, with length of copper wire contained within, 1 3/4" long. Wire has been cleaned and the high luster of the copper is visible. L. Tube like K, 3" long, but with no visible copper. M. Conventional fulgurite in sand, from a Minnesota lake shore.

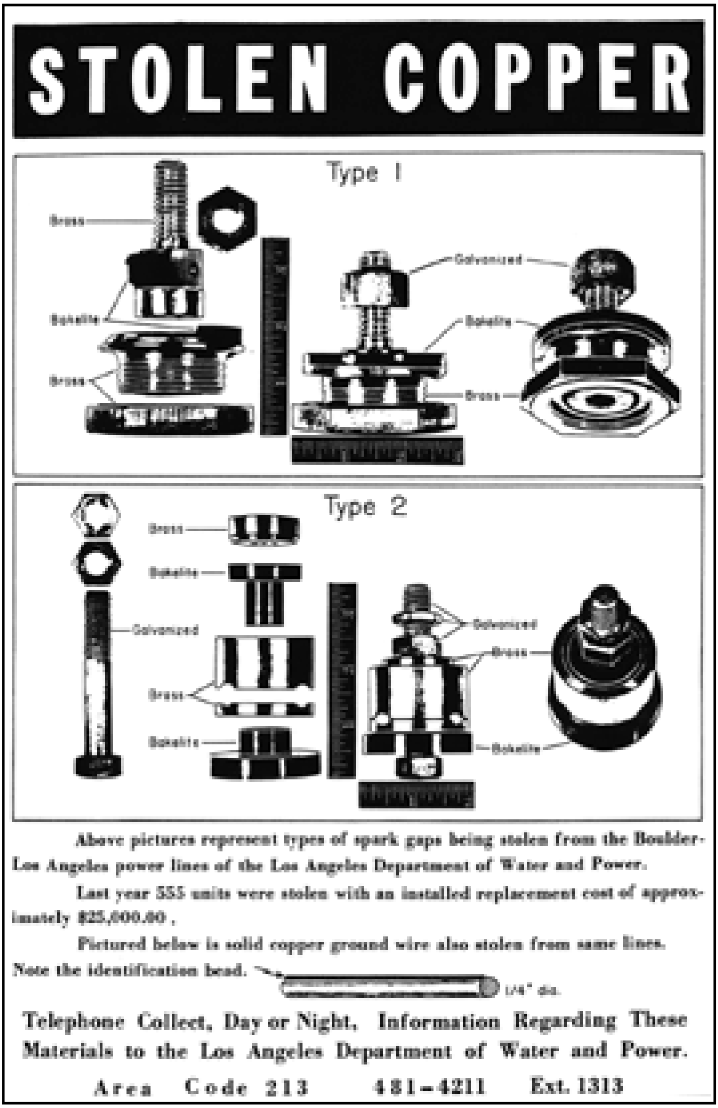
desert road was passable. Remains of such a trail do pass within 300 yards of the fulgurite locality.

Fulgurite tubes in bedrock suggest that: (a) the temperature was considerably higher than is customarily generated in lightning strikes; (b) there was a large amount of water in the rock material — either in its bulk composition or as circulating ground water; or (c) the rock was low in silica which might fuse under temperatures expected when lightning strikes. The fact that tubes are rare in bedrock suggests that normal conditions preclude sufficiently high temperatures, even though there is adequate moisture, to produce pure melting — at least in common environments. Spalling of rock and shatter features are by far the most common expressions of lightning strikes, even where water, which reduces the temperature needed for fusion, is most plentiful. In 1884, J. S. Diller reported what appeared to him to be one small tube in bedrock on Mt. Thielsen in Oregon. However, W. B. Purdom reported in 1966 that he was unable to find fulgurite tubes in the area. He speculated that the tube in bedrock may have been simply an enlargement of vesicular structures already begun in tubular form.

The fulgurites we saw in the desert were in an area where surface water is absent, and (being in quartz diorite) the normal percentage of water in the rock is low. High temperature, therefore, was apparently the direct cause of these fulgurites. The specimens show walls of vesicles that are circular in cross-section and spherical. Such symmetrical vesicles have been explained as developing primarily from melting where the temperature was high enough to boil the glass produced. Baker and Gaskin, in a study of glasses from Australia, most of which are low in water content, found that temperatures of 2500°C were required to develop pure silica glasses. In rocks lower in silica and higher in amphiboles, with some constituent water, temperatures as low as 1000°C created fusion where rocks carried as little as 68 percent silica.

Artificial fulgurites have been noted in sand, from a locality also in Riverside County[2]. At this place, a 16,500-volt power line broke, and because of a faulty safety switch, current flowed for some time into the sand before it was shut off. This produced artificial conventional fulgurites, except that the artificial fulgurites tended to be solid rather than hollow tubes, probably because of continuous rather than intermittent discharge of the electricity.

In the case of the bedrock fulgurites, it is suggested that the copper on the ground acted as an attracting force for the lightning. The rate at which lightning is discharged is in terms of microseconds, with many discharges occurring in a so called



STOLEN COPPER

Type 1

Type 2

Above pictures represent types of spark gaps being stolen from the Boulder-Los Angeles power lines of the Los Angeles Department of Water and Power.

Last year 555 units were stolen with an installed replacement cost of approximately $25,000.00 ,

Pictured below is solid copper ground wire also stolen from same lines. Note the identification bead.

1/4" dia.

Telephone Collect, Day or Night. Information Regarding These Materials to the Los Angeles Department of Water and Power.

Area Code 213 481–4211 Ext. 1313

Sample circular of Los Angeles Department of Water and Power, designed to assist in reducing theft of copper wire. Size of wire in fulgurite similar to that of circular.

[2] *Ibid.*

single lightning stroke. Although a single stroke is seen by the eye, it consists in fact of several or many strokes. If copper was the attractor, the conductivity of the copper would tend to dissipate rather than concentrate the heat. However, heat could be concentrated if lightning repeatedly struck at the same points or in the same small radius—which one would expect where a coil of wire lay exposed.

The country rock in the vicinity of the strike is consistently high in magnetite as an accessory mineral, but this has not apparently affected the discharge, since the focal point has been the copper and not in the country rock. It appears that repeated heat applications can provide sufficient heat to melt minerals like quartz at lower temperatures (1400°C), but rapid melting requires high temperatures (1800°C). That the vesicles have circular sections suggests the higher temperatures, however.

The desert regions of California are logically areas where fulgurites would be relatively plentiful, because of the greater number of lightning storms. This is possibly the second, but most probably the third, report of fulgurites in dune sand from north of Point Happy, was made by H.E. Vokes in 1939. The second, of fulgurites in sand probably derived from granodiorite, was made by A.F. Rogers in 1946. It is possible that the locality described herein may be the same as Dr. Rogers', for his description indicates considerable similarity between the fulgurites; however, I consider it unlikely. Though the prospector who provided Dr. Rogers with his fulgurite sample did not divulge the exact spot where he collected it, he did note the minerals in it — but mentioned no copper. Such an omission is scarcely credible, had the localities been identical.

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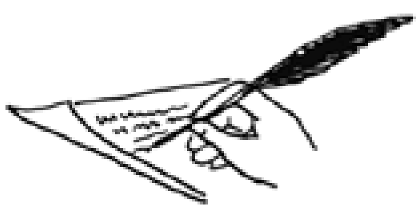

THE EVENT

PETRIFIED LIGHTNING FROM CENTRAL FLORIDA

A PROJECT BY ALLAN MCCOLLUM

CONTEMPORARY ART MUSEUM
UNIVERSITY OF SOUTH FLORIDA

MUSEUM OF SCIENCE AND INDUSTRY
TAMPA, FLORIDA