mak[19] seems to the writer to be a decided improvement. It is as follows:

Dana		Tschermak
001	=	100
010	=	010
100	=	$10\bar{1}$
$\bar{1}01$	=	001
011	=	120
110	=	$12\bar{1}$

With this new orientation the phillipsite group, like all the other fibrous zeolites and many other fibrous minerals, is elongated in the vertical direction instead of parallel to *a*. Furthermore, the experiments of Rinne[20] on stilbite show that when it becomes orthorhombic at about 250°C. the axes Y and Z coincide with Dana's axes *b* and *a*, but X is normal to 001 and not parallel with *c*. With Tschermak's orientation the orthorhombic substance has $X=a$, $Y=b, Z=c$.

(To be continued)

A FULGURITE FROM SOUTH AMBOY, NEW JERSEY[1]

W. M. Myers[2] and Albert B. Peck[3]

Fulgurites, the glassy irregular tubes produced by the fusion of sand or siliclous soil, which has been struck by lightning, have attracted attention from very early times. Their rare occurrence, unusual appearance and association with localities where lightning has been observed have lead to many strange conjectures concerning them. Before the true nature of lightning had been established by Franklin, there was even some popular belief that they were the actual "thunder bolts" which descended from the sky.

The infrequency with which fulgurites are encountered together with the difficulty of extracting them from the surrounding soil and the fact that their true identity often is not recognized has

[19] *N. Jahrb. Min.*, 1897, **I,** p. 41.

[20] *Sitz. Akad. Wiss. Wien,* **CXXVI,** 1917, p. 541 and **CXXVII,** 1918, p. 177.

[1] Published by permission of the Director of the Bureau of Mines, Department of the Interior.

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resulted in the recovery of very few specimens and many mineralogical museums are without a representative.

Through the courtesy of Prof. G. H. Brown, Director of the Department of Ceramics of the State University of New Jersey, the writers have had the opportunity of examining a fulgurite which was found last year at South Amboy, New Jersey. This fulgurite was encountered in the sand pits operated by the Crossman Company during the operations attendant to the removal of the sand for industrial uses. Unfortunately it was badly broken during its removal and few pieces were extracted having a length greater than six inches. This is said to be at least the third fulgurite which has been found in this locality.

The length of the pieces recovered totaled nine feet. It is probable that the original length was in the vicinity of eleven feet. The greatest diameter observed was three inches, which gradually decreased to three sixteenths of an inch. The taper was very gradual and was marred only in a few places by sudden expansions in diameter. Evidence was found of only one branch from the main stem; aside from this the fulgurite originally was one continuous conical rod. The surface was exceedingly rough and covered with excrescences measuring from one-sixteenth to one-half inch in length. The entire surface was coated with partially fused grains of sand. The exterior color varied from yellow and light brown to a dull white. The glass of the interior was an opaque white due to the inclusion of bubbles. Where these were lacking a typical transparent glass was found. Black stained areas, probably due to the presence of iron oxides, were noted in some sections.

The most marked feature of the fulgurite was the hollow core which extended almost its entire length. In places this had been filled with glass; in others it became so pronounced that the fulgurite became a thin shell. At one point where the diameter was three-eighths of an inch, the walls had a thickness of one thirty-second of an inch. Cross sections display a very pronounced radiating structure from this core. Even the included bubbles are elongated and are arranged with their long axes pointing toward the center. These bubbles are so abundantly disseminated throughout the glass that the glass itself is divided into a mass of radiating needles. The gaseous inclusions were so numerous that the specific gravity of the glass was greatly lowered. The apparent gravity, determined with a Jolly balance, showed variations from 1.05 to

1.25, with an average of 1.14. All portions of the fulgurite were exceedingly brittle and could be crushed readily in the hands.

Chemical analysis of a representative section is as follows:

(Analysis by Mr. E. E. Berger)

SiO_2	99.00
Al_2O_3	.70
Fe_2O_3	.30
	100.00

The sand surrounding the fulgurite was composed of quartz grains discolored with a small amount of limonite and containing a small amount of a clay-like mineral. The fulgurite appears to be the product of the direct fusion of these materials. Typical sections were examined with the petrographic microscope to determine what changes in mineral composition had taken place.

The bulk of the fulgurite was found to be composed of an isotropic glass having an index of refraction of 1.462 ± 0.003, typical of silica glass. No difference was observed from the center toward the outer edge except in the number of bubbles. A few areas of parallel needles possessing high index, parallel extinction, and positive elongation were found to be present in places. These are probably the mullite ($3Al_2O_3.2SiO_2$) of Bowen.[4] The grains adhering to the exterior of the fulgurite were found to have a quartz center surrounded with a fine grained border of cristobalite. The enormous energy liberated by lightning, sufficient to fuse quartz, would undoubtedly be sufficient to dissociate any clay-like mineral and recombine its alumina content with quartz, forming mullite.

Much room is left for conjecture concerning the mechanics of the formation of a fulgurite. A bed of sand with its comparatively uniform mineral composition and corresponding uniform electrical resistance, composed largely of one mineral readily fusible at the temperature attained, presents ideal conditions. At least fulgurites from other sources are rare, although a similar phenomena caused by lightning striking rocks has been reported. The tube-like structure may be due in part to the sudden cooling which must have been rapid or glass would not have resulted. It may also be

[4] Mullite, a silicate of alumina. N. L. Bowen, J. W. Grieg, E. G. Zies, Jr., *Wash. Acad. Sci.*, **14,** 183-191 (1924).

due to the fact that the volume of sand which was fused to glass must have been much greater than the volume of the resultant glass, leaving a crude cylindrical mould to whose sides the glass was drawn by cohesion while in a viscous state. The included bubbles have most probably arisen from moisture entrapped during the sudden fusion of the sand, wet from the storm, or perhaps in part from volatilization of silica or other components into a gaseous form when the bolt struck. The presence of mullite is undoubtedly due to the short time the mass was liquid, thus giving the alumina of the clay insufficient opportunity to be thoroughly disseminated through the silica glass for complete solution. Hence, at points of high local concentration of alumina, mullite was formed.

Since the above note was written, Prof. A. F. Rogers has called our attention to the fact that Lacroix has given the name "lechateliérite" to the glass of fulgurites.[5] He does not, however, mention the presence of mullite. Professor Rogers[6] detected water, upon heating in a closed tube a fulgurite containing many bubbles, thus confirming our conclusion that the bubbles are due to entrapped steam.

BOOK REVIEWS

MIKROSKOPISCHE PHYSIOGRAPHIE DER MINERALIEN UND GESTEINE. Rosenbusch-Wülfing, 5th edition, fully revised. Vol. I, First Half, octavo, pages 533–846. The whole volume contains 680 figures and 15 plates. E. Schweizerbart'sche Verlagsbuchhandlung, *Stuttgart,* 1921-1924.

This is the third and last section of volume one. (For reviews of the first two sections see *Am. Min.*, **7**, 211, 1922, and **8**, 172, 1924.

The discussion of the microscope and its uses is completed. The other subjects considered are the use and application of the axial angle apparatus and of the conoscope; investigation of cohesion and density; methods of separation; and chemical methods. The morphological features of crystals are treated in four chapters as follows: (a) Formation, (b) Inclusions, (c) Aggregates, and (d) Deformations. The appendix includes tables of indices of refraction, birefringence, and specific gravities, as also plates of photomicrographs of thin sections of rocks and minerals, and of chemical preparations as well. E. H. Kraus.

THE STRUCTURE OF CRYSTALS. Ralph W. G. Wyckoff. American Chem. Soc. Monograph Series. Chemical Catalog Company. 19 East 24th St., *New York,* 1924. 462 pp. 231 fig. Price $6.00 net.

This book consists of two parts; the first dealing with theory and methods, the second with results.

[5] *Bull. Soc. Fr. Min.*, **38,** 182-6 (1915).

[6] *Jour. Geol.,* **25,** 526 (1917).