THE QUARTZOFELDSPATHIC FULGURITE OF BUSTAVIEJO (MADRID): GLASSY MATRIX AND SILICON PHASES. J. Garcia-Guinea, M. Furio, M. Fernandez-Hernan, M.A. Bustillo, E. Crespo-Feo, V. Correcher, L. Sanchez-Muñoz and E. Matesanz, Museo Nacional Ciencias Naturales-CSIC, Jose Gutierrez Abascal 2, Madrid 28006, Spain; CIEMAT, Avenida Complutense 22, Madrid 28040, Spain; Centro de Apoyo a la Investigacion de DRX. Univ. Complutense Madrid. 28040, Spain. Correspondence author: mfurio@mncn.csic.es

Introduction: Fulgurites are glassy irregular tubes produced by the fusion of sand, which has been struck by lightning. They have attracted attention from very early times, e.g. in Spain a fulgurite was described and outlined (Fig. 1), in the XII Century, at 1250, in the medieval book, Lapidary of King Alfonso X The Learned [1], kept in the Escorial monastery main library, as the stone number 206, labelled mazintarica, i.e., an ancient Chaldean term.

The pioneering publication of Myers & Peck at 1925 [2] on the sand-claystone fulgurite of South Amboy (New Jersey, USA) describes quartz centers surrounded with a fine grained border of cristobalite and black stained areas attributed to possible iron oxides. The extreme reduction produced by lightning strike fusion and the discovery of silicon and silicon-iron alloys was later described in natural fulgurites [3-4]. Additional findings of fulgurites from other rocks were also studied with luminescence and stable isotopes techniques [5-8]. Here we studied the fulgurite components by both, classic and modern spectral and electron microscopy techniques to learn more on the different silicon phases.

Fulgurite samples and experimental: We found, and study, a glassy quartzofeldspathic fulgurite, formed recently on arkose sediment which covers granite rock of Bustarviejo village (Madrid, Spain). Quartzofeldspathic fulgurites formed from arkosic sediments are highly vesicular but does not develop pipelike shapes as the case of those formed in only quartz sands. The Electron Probe Microanalyses (EPMA) were performed in a Jeol Superprobe JXA-8900M and also by Environmental Scanning Electron Microscopy with X-ray Dispersive Spectrometry probe (ESEM-EDS) in an Inspect-S ESEM of the FEI Company. The in situ high-temperature X-ray diffraction (HTXRD) fulgurite patterns were recorded from room temperature (RT) to 1200°C using a Panalytical X-Pert PRO MPD diffractometer (Cu Kα radiation, 45 kV, 40 mA) equipped with a high-temperature Anton Paar HTK1200 camera and a fast detector X'Celerator with Ni β filter. During circa 17 h, we performed 76 HTXRD profiles from RT to 1200°C, with gaps of 10°C/min between each XRD profile. The Thermoluminescence (TL) measurements of fulgurite were performed using an automated Risø TL system model TL DA-12 with an EMI 9635 QA photomultiplier. The emission was observed through a blue filter FIB002 in which the wavelength is peaked at 320–480 nm. The hyperspectral Raman quartz and cristobalite distribution was explored with a ThermoFisher Raman Microscope which has a point-and-shoot Raman capability of one micron spatial resolution using a laser source at 532 nm.

Results and Discussion: The Bustarviejo fulgurite is made of aluminosilicate glass, shocked quartz, and neo-formed cristobalite. The sphaeroidal vugs, sized from micron to centimeter, exhibits black spot of native Si-Fe-Al alloys, with different ratios, which unmixed from an aluminosilica-rich melt. (Fig. 2).
The EPMA analyses of glasses display the following compositional ranges (%): SiO$_2$ (63–70.68), Al$_2$O$_3$ (19.00–23.63), FeO (0.06–2.09), CaO (0.04–0.74), Na$_2$O (0.03–0.17), K$_2$O (0.09–0.96), P$_2$O$_5$ (0.01–0.016) as the most representative elements. The top analyzed amount CaO (0.74) and Na$_2$O (0.17) stem from the same sample, i.e., a single former grain of plagioclase. The thermal variations of low quartz and low cristobalite were observed by HTXRD. At circa 247°C, the low-high cristobalite phase transition occurs; at 540°C the low-high quartz and finally beyond 1100°C the quartz peak at 26.47 2θ splits arising a little peak which disappears beyond 1180°C. The experimental TL glow curve of the fulgurite is composed by a broad band peaked at 233°C–123 a.u. and two peaks at 460°C–500 a.u. and 494°C–1500 a.u., unfortunately, these values do not allow us to perform TL dating since the surrounding sediment. i.e., quartz plus alkali feldspars display a huge TL emission peak at 223°C–571 000 a.u. and 274°C–417 000 a.u., only let us to confirm that it is a geologically recent strike older than circa 30 years which is the time being observed by the surrounding population. The main part of the glassy matrix exhibits a molecular-Raman structure similar to a synthetic gel of potassium aluminosilicate obtained experimentally via sol-gel. The hyperspectral Raman contour plots of quartz grains outline its cristobalite outer comparing characteristic maxima peaks at 465 cm$^{-1}$ (Quartz) and 415 cm$^{-1}$ (Cristobalite) (Fig. 3). Both data, i.e., spot of plagioclasic glass and cristobalitic boundaries of the inlaid quartz grains, let us to infer on the short time lightning strike. This fulgurite sized 12 cm in diameter in the main branch, was formed by lightning strike fusion on arkosic sand during a fast process of volatilization and extreme reducing conditions at temperatures in excess of 2000 K [4].

References:

Acknowledgements. Supported by the project CGL-20008-05584-CO2-01, and a JAE-Doc CSIC contract.