

**METEORITES FROM COMET 2P/ENCKE: A METEORITE-PRODUCER TAURID FIREBALL RECORDED IN 2021.** A. San Segundo<sup>1</sup>, J.M. Madiedo<sup>2,3</sup>, J.L. Ortiz<sup>2</sup>, J. Aceituno<sup>4</sup>, E. de Guindos<sup>4</sup>. <sup>1</sup>Observatorio El Guijo (MPC J27), Galapagar, Madrid, Spain. <sup>2</sup>Instituto de Astrofísica de Andalucía, CSIC, Apt. 3004, Camino Bajo de Huétor 50, 18080 Granada, Spain. <sup>3</sup>Observatorio Galileo, 41012 Sevilla, Spain. <sup>4</sup>Centro Astronómico Hispano-Alemán, Calar Alto (CSIC-MPG), E-04004 Almería, Spain.

**Introduction:** It has been established that the Taurids contain very large (even meter-sized) meteoroids [1]. In fact, since the Taurid complex is thought to have originated through the cascade disintegration of a large comet, the existence of these large fragments is not surprising. This stream is also known for producing very bright fireballs [2]. In addition, it has been found that some of these meteoroids exhibit very large tensile strength values [3]. This, together with a not too high entry velocity for particles from this stream (around  $28 \text{ km s}^{-1}$ ), led some authors to propose that the Taurids could be regarded as potential meteorite-producers [2]. In fact, along the last decade several deep-penetrating Taurid bolides with non-zero terminal mass have been reported in the scientific literature, although said mass was always small (a few grams), and the resulting meteorites could not be recovered [2, 4]. In this context, we present here the preliminary analysis of a potential meteorite-dropping Taurid event observed over the Iberian Peninsula on 2021 November 12. This extraordinary event was recorded and analyzed in the framework of the Southwestern Europe Meteor Network (SWEMN) and the survey that this network conducts to analyze the interaction of meteoroids with the Earth's atmosphere: the SMART project (Spectroscopy of Meteoroids in the Atmosphere by means of Robotic Technologies), which was started in 2006 [5].



Figure 1. Sum-pixel image of the fireball discussed in this work, as recorded from El Guijo Observatory (MPC J27).

**Instrumentation and methods:** To record the fireball analyzed in this work we have employed an array of low-lux CCD video cameras manufactured by Watec Co. (models 902H and 902H2 Ultimate). These devices monitor the night sky and operate in a fully autonomous way by means of software developed by J.M. Madiedo [5]. The atmospheric trajectory and orbital data of the event were obtained with the Amalthea software [5]. To obtain the emission spectrum of the fireball, we have employed videospectrographs based on the same cameras, endowed with holographic gratings (1000 lines/mm).

**Preliminary analysis:** The fireball presented in this work (Figure 1) was recorded on 2021 November 12 at  $0\text{h}34\text{m}48\pm1\text{s}$  UT from several of the meteor-observing stations operated by SWEMN and SMART in Spain: El Guijo (Madrid), Sevilla, Sierra Nevada, and La Hita (Toledo). The emission spectrum of the bolide was also obtained. The analysis of the atmospheric trajectory of the event reveals that the luminous phase started at an altitude  $H_b=96.7\pm0.4 \text{ km}$  over the east of the province of Salamanca. The meteoroid stroke the atmosphere with a velocity  $V_\infty$  of about  $28.5 \text{ km/s}$ . The apparent radiant was located at the equatorial coordinates  $\alpha=55.6^\circ$ ,  $\delta=16.5^\circ$ . The bolide penetrated the atmosphere till a final height  $H_e=25.0\pm0.4 \text{ km}$  over the same province. The projection on the ground of the atmospheric trajectory is shown in Figure 2. The parameters of the heliocentric orbit followed by the meteoroid before its encounter with our planet are shown in Table 1. These data confirm the association of the event with the Southern Taurid meteoroid stream.

The analysis of the lightcurve of the bolide reveals that the peak luminosity of the fireball, which exhibited several flares along its path in the atmosphere, corresponded to an absolute magnitude of  $-13\pm1$ . These flares took place as a consequence of the sudden disruption of the progenitor meteoroid when the aerodynamic pressure exceeded the tensile strength of the particle [6]. From the analysis of these breakups we estimated that the tensile strength of the meteoroid was of about  $(2.4\pm0.5)\cdot10^7 \text{ dyn/cm}^2$ .



Figure 2. Projection on the ground of the atmospheric path of the bolide.

Our calculations also reveal that the meteoroid was not completely ablated in the atmosphere, since at the terminal point of the luminous trajectory a mass of about 20 g survived the ablation process. The dark flight was also analyzed and the landing area of the surviving mass was determined. An expedition was organized to that area, where experts in meteorite recovery participated in collaboration with SWEMN. Unfortunately, it was found that part of the predicted landing area had just been plowed, and the meteorite was not found.

<b>a (AU)</b>	$2.6 \pm 0.1$	<b><math>\omega</math> (°)</b>	$101.6 \pm 0.1$
<b>e</b>	$0.82 \pm 0.01$	<b><math>\Omega</math> (°)</b>	$49.51242 \pm 10^{-5}$
<b>q (AU)</b>	$0.455 \pm 0.004$	<b>i (°)</b>	$3.7 \pm 0.1$

Table 1. Orbital data (J2000) of the progenitor meteoroid.

**Conclusions:** We have presented a preliminary analysis of a mag.  $-13 \pm 1$  fireball observed over Spain on 2021 November 12. The bolide was recorded and studied in the framework of the SWEMN network and the SMART project. The calculated radiant and orbital parameters show that the progenitor meteoroid belonged to the Southern Taurid stream. The bolide penetrated the atmosphere till a final height of  $25.0 \pm 0.4$  km. The conditions determined at the ending point of the luminous trajectory reveal that the meteoroid was not completely destroyed in the atmosphere, and that a terminal mass of about 20 g survived the ablation process and. An expedition was organized to the landing area of the resulting meteorite, but unfortunately the

surviving mass was not found. Nevertheless, this event exemplifies the ability of large and tough Taurid meteoroids to produce meteorites.

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