

HISTORICAL RECORDS OF δ -ARIETIDS SUPERFIREBALLS OVER SPAIN. J.M.Madiedo¹ and J. M. Trigo-Rodríguez^{2,3}. ¹Facultad de Ciencias Experimentales, Universidad de Huelva, Spain (madiedo@uhu.es); ²Institut d'Estudis Espacials de Catalunya. Gran Capità 2-4, Ed. Nexus. 08034 Barcelona, Spain; ³Institut de Ciències de l'Espai-CSIC. Campus UAB, Facultat de Ciències, Torre C5-p2. 08193 Bellaterra, Spain.

Introduction: Historical reports of bright fireballs are useful to better understand which meteoroid streams can be tentatively associated with meteorite-dropping events [1]. We present here a preliminary analysis of a very remarkable event that took place over Spain on Dec. 8, 1932 and the evidences that support its likely connection to the δ -Arietids meteor shower. Besides, there is evidence that indicate that another very bright, although less important, event was witnessed over the same region during the same day could be also associated to this shower. The δ -Arietids is a minor shower which is included in the IAU working list of meteor showers with the code 289 DNA [2]. Very few data exist for this radiant and, so, any new contributions about it are of great interest.

The densities calculated for δ -Arietids meteoroids are comprised between 2000 and 5000 kg/m³, which suggest that their parent body must be an asteroid [3]. Thus, one NEO, asteroid 1990 HA (217628 Lugh), has been proposed as the parent body for this shower [4]. This is an Apollo family asteroid with a diameter of about 1.4 km which is catalogued as a PHA. Moreover, this shower has been proposed as a candidate for potential meteorite dropping events, and one fireball recorded on Dec. 13, 1975 is believed to have produced a meteorite with a surviving terminal mass of about 290 g. [3, 4]. 1990 HA is not, however, the only NEO which has been reported to be able to produce meteorites. Thus, recently, asteroid 2002NY40 was proven to be the source of meteorite dropping bolides [5].

Available data on the December 8, 1932 events:

On December 8, 1932, at about 23:30 local time (22:30 UT), with the sky partially covered of clouds and under a light rain, a large fireball was witnessed by the inhabitants of Arroyomolinos de León, a village located in south-western Spain, in the province of Huelva. The eyewitnesses reported that the bolide followed a trajectory with a low zenith angle, falling almost vertically towards the village. From the description given by some of the eyewitnesses, the fireball followed a north-east direction. It exploded in the air, generating a deafening sound. Besides, damages of different consideration were reported to be caused by the air blast in several buildings and facilities. However, no crater was produced and no meteorite fragments were found to our knowledge.

Several hours before and under daylight conditions, in the afternoon of the same day, at about 17:00 local time (16:00 UT), another bright event was reported to be seen from the village of Galaroza, which is located at about 28 km from Arroyomolinos de León. The eyewitnesses claimed that this fireball crossed the sky very slowly, in a kind of Earth-grazing trajectory.

The nature and origin of both events remained unknown till today, and, without any recorded images of those events, these were just kept by the oral and written tradition of the inhabitants of both villages.

The complete reconstruction of both events is very difficult, as no photographic records exist. However, the analysis of the eyewitnesses descriptions suggest that both events are compatible with the δ -Arietids. The first clue for this link arose from the fact that they took place during the maximum of this meteor shower (solar longitude: 256.5°). Besides, the reported slow angular velocity of both events is also consistent with this shower, for which the pre-atmospheric velocity is just of about 14.6 km/s.

On the other hand, by the time of appearance of the fireball seen from Arroyomolinos de León, the radiant of the δ -Arietids (RA: 53°, DEC: 29°, J2000) was located at a zenith angle of about 80 degrees, with an azimuth of 220°. This result is consistent with the reports that assert that the fireball was seen to fall almost vertically towards the village and moving north-east and, so, it supports the link with this radiant.

Besides, the radiant of the δ -Arietids meteor shower was just above the local horizon, with a height of about 17 degrees when the Galaroza fireball was witnessed. This would imply an Earth-grazing nature for this fireball. As a consequence of this and of the low preatmospheric velocity of the δ -Arietids (14.6 km/s), this event should have had a very low angular velocity, which would explain the reported high duration of this fireball in the sky. However, very few data exist for this event and the direction that this fireball followed in the sky is unknown. So, its likely connection with the δ -Arietids cannot be established on a solid basis.

Energy considerations: The air blast caused by the explosion of the fireball witnessed from Arroyomolinos de León was responsible for the damages reported in several buildings and facilities in this village. Glass windows shattering and damages in some build-

ings are some of the effects described. Of course, without any video or photographic data available to perform a detailed analysis it is not possible to precisely calculate the height at which the meteoroid exploded and its corresponding initial or terminal mass. However, by using the software developed by Collins et al. [6] it is possible to estimate the energy released by this event by taking into account some of the effects reported by the eyewitnesses and the parameters of the δ -Arietids shower. Thus, glass windows shattering and very loud noise, comparable to nowadays heavy traffic, have been used as a reference to estimate the energy of this event. This, together with an impact angle of 80 degrees and an initial velocity of 14.6 km/s, reveal that the observed effects would have been produced by a meteoroid with an initial diameter of about 18 meters and a density of about 3500 kg/m³. This implies that the energy released by the airburst was of the order of $8.06 \cdot 10^{14}$ J (0.19 Megatons of TNT). Under those circumstances, the meteoroid would have exploded in the air at a height of about 15.7 km.

Conclusions: The event witnessed on Dec. 8, 1932 from Arroyomolinos de Leon is consistent with the δ -Arietids meteor shower and with the fact that this radiant can give rise to meteoroids with considerable initial mass to produce airbursts as these studied in [1]. This hypothesis also supports the fact that the δ -Arietids can give rise to potential meteorite drop events. This is also consistent with other reports about NEOs which are potential meteorite droppers [5]

Oh the other hand, the event witnessed the same day from Galaroza could also belong to the same radiant, although the lack of data does not allow establishing this on a more solid basis.

References: [1] Napier B. and D. Asher (2009) *Astronomy & Geophysics* 50, 18-26. [2] Jenniskens P. (2006) in *Meteor Showers and their parent comets*, Cambridge University Press, 748-751.. [3] Halliday I. et al. (1996) *Meteoritics & Planet. Sci.*, 31, 185-217. [4] Langbroek, M. (2003) *WGN*, 31, 177-182. [5] Trigo-Rodríguez, J.M. et al. (2007) *Mon. Not. R. Astron. Soc.* , 382, 1933-1939. [6] Collins G. S. et al. (2005) *Meteoritics & Planet. Sci.* 40, 817-840.