ON THE PARENT BODY OF THE NORTH. OMEGA-SCORPIID METEOROID STREAM. J. Segura[1], J.M. Madiedo[1,2], J. Izquierdo[1]. [1]Facultad de Ciencias Experimentales, Universidad de Huelva, Huelva, Spain. [2]Departamento de Física Atomica, Molecular y Nuclear. Universidad de Sevilla. 41012 Sevilla, Spain.

Introduction: During the end of May and mid June, meteor and fireball activity from the Scorpiid-Sagitariid complex can be noticed. One of the streams belonging to this meteoroid complex is the North ω-Scorpiids, which was previously designated by some authors as the χ-Scorpiids [1]. The North ω-Scorpiid shower is included in the IAU working list of meteor showers with the code 66 NSC (http://www.astro.amu.edu.pl/~jopek/MDC2007/). Its activity period goes from May 23 to June 15 with a maximum around June 1st. At its peak activity, its zenithal hourly rate (ZHR) is of around 5. The Apollo-type orbit found for NSC meteoroids let Drummond to propose 1862 Apollo as the parent asteroid of this meteor shower. Nowadays, however, Asteroid 1996 JG is included among the potential parent bodies of this stream [1].

In this paper we present data that support the idea that Asteroid 1996 JG is the parent NEO of the NSC meteoroid stream. Thus, we analyze a series of NSC meteor and fireball events recorded over Spain between 2010 and 2012. The orbit of the corresponding meteoroids have been calculated. The likely association with 1996 JG is established from the analysis of the evolution with time of the orbit of the NSC stream obtained from our meteor survey. In addition the emission spectrum of a bright NSC meteor is presented and analyzed. This spectrum has provided some information about the likely nature of the progenitor body of the North ω-Scorpiids.

Instrumentation and methods: An array of low-light CCD video cameras (models Wate 902H and 902H2 Ultimate) was employed to obtain meteor atmospheric trajectories and meteoroid orbits by triangulation. These devices operated in the framework of the Spanish Meteor Network (SPMN). Each station employed between 4 and 12 cameras, and the field of view covered by each device ranged from 62x50 to 14x11 degrees, approximately. A detailed description of these systems can be found in [2, 3]. The reduction of the images recorded by these cameras was performed with the AMALTHEA software, which was developed by the second author and calculates atmospheric trajectories and meteoroid orbits by following the methods described in [4].

To obtain meteor emission spectra, holographic diffraction gratings were attached to the lens of some of the above-mentioned Watec cameras. The configuration of these videospectrographs is explained in [5]. The NSC spectrum recorded in the framework of this spectroscopic survey was analyzed with the CHIMET software, also developed by the second author.

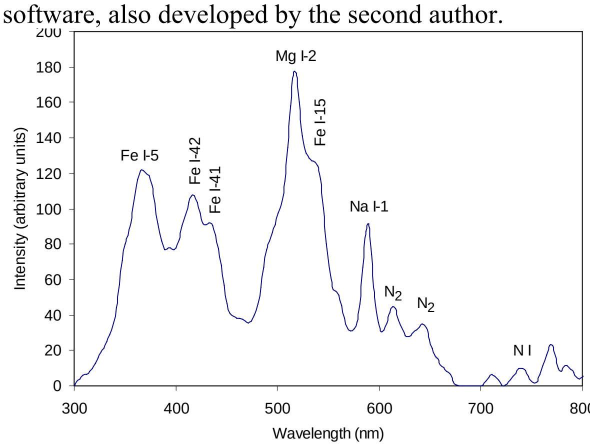

Figure 1. Calibrated emission spectrum of the 060610 NSC fireball.

Observations: Optimal weather conditions in the South of Spain during most of the months of May and June favoured the monitoring of meteor activity related to the NSC meteoroid stream between 2010 and 2012. In total, 11 double-station NSC meteor trails were imaged in the time period from May 23 to June 15, with absolute magnitudes M ranging from 1.5 to -8.5. One emission spectrum resulted from our spectroscopic survey. Thus, on June 6, 2010 a videospectrograph imaged the emission spectrum (Figure 1) of the mag. -8.5 ± 0.5 NSC meteor with code 060610.

The candidate as parent body of the NSC stream, obtained from an orbital analysis, was the PHA 1996 JG, with D_{SH}=0.07. We have integrated backwards in time the orbits of 1996 JG and the NSC meteoroid stream with the Mercury 6 orbital integrator in order to test if this association could be established on a solid basis. This integration was performed for a time period of 30,000 years since the current epoch, and by taking also into account the gravitational fields of Venus, Earth, Moon, Mars, Jupiter and Saturn. The resulting evolution of the D_{SH} function with time is plotted in Figure 2, which shows that D_{SH} remains below 0.15 for a time period of around 28,000 years. This reveals the similarity between the orbital elements of the asteroid and the NSC stream. So, we can conclude that, on the basis of orbital dissimilarity criteria, Asteroid 1996 JG can be establish as a potential parent body of the NSC meteoroid stream. Nevertheless, it is important to point out that dissimilarity criteria by themselves cannot establish unambiguously which is the parent body of a meteoroid stream, since the dissimilarity function can only establish a potential link with a given minor body. Thus, there could be an as yet undiscovered NEO that could provide a better fit.

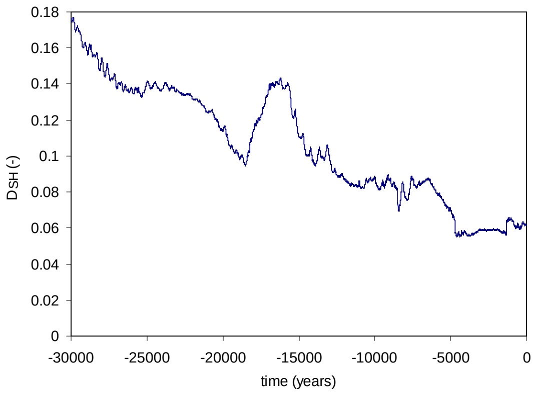

Figure 2. Evolution from present time of the D_{SH} criterion for the NSC meteoroid stream and PHA 1996 JG.

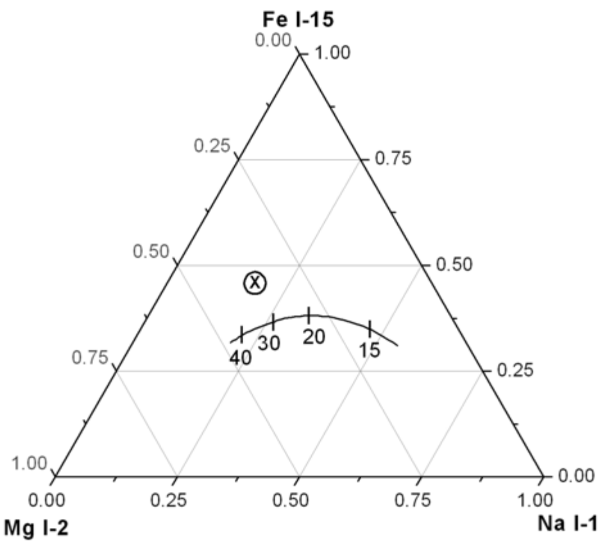

Figure 2. Expected relative intensity (solid line), as a function of meteor velocity (in km s^{-1}), of the Na I-1, Mg I-2 and Fe I-15 multiplets for chondritic meteoroids [6]. Cross: experimental relative intensity for the 060610 NSC meteor; circle around cross: uncertainty (error bars) for this experimental value.

A remarkable feature of the 060610 spectrum is the relatively low intensity of the Na I-1 line in relation to the Mg I-2 emission. The likely reason for this is the depletion of sodium in the progenitor meteoroid with respect to the expected value for chondritic materials. This was confirmed by measuring the relative intensities of the emission lines of multiplets Na I-1, Mg I-2 and Fe I-15. This measurement provided the following intensity ratios: Na/Mg = 0.47 and Fe/Mg = 1.25. As expected, the Na/Mg intensity quotient does not fit the expected value for meteoroids with chondritic composition for a meteor velocity of ~ 22 km s^{-1}, as Figure 5 in [6] shows. The depletion in Na is clearly seen in the ternary diagram shown in Figure 3. This plot shows the expected relative intensity of the Na I-1, Mg I-2 and Fe I-15 lines for chondritic materials as a function of the velocity of the meteor (solid line) [6]. The cross in this diagram shows the value measured for the 060610 spectrum, which significantly deviates from the chondritic value for a meteor velocity of around 22 km s^{-1}. Since the perihelion distance is too large ($q = 0.639 \pm 0.004$ AU) to explain this depletion on the basis of an excessive approach to the Sun, this composition is most likely related to a non-chondritic nature of the parent body. Unfortunately no spectrophotometric data are available for Asteroid 1996 JG to check this. A positive correlation between the composition of NSC meteoroids and 1996 JG could provide an additional argument to establish this PHA as the progenitor of the Northern ω-Scorpiid stream.

Conclusions: The monitoring of the night sky during the activity period of the North ω-Scorpiids provided 11 double-station NSC events and the emission spectrum of one member of this shower. The Tisserand parameter with respect to Jupiter and the constancy of the initial height of the luminous trajectory as the mass of the meteoroid increases shows that this stream has an asteroidal origin. On the basis of the Southworth and Hawkins dissimilarity function we have found that the potentially hazardous asteroid 1996 JG is a solid candidate to parent body of this meteoroid stream. Thus, the orbit of the NSC stream and that of this PHA remain similar during a time period of about 28,000 years in the past, with $D_{SH}<0.15$ during this interval.

The emission spectrum recorded for a mag. -8.5 NSC meteor exhibited as main contributions the emission lines of Mg I-2 and several Fe I multiplets. The Na I-1 line, however, was dimmer than expected for meteoroids with a chondritic composition. The analysis of the relative intensities of Mg I-2, Fe I-15 and Na I-1 in this signal confirmed a depletion of Na with respect to the chondritic value. The perihelion distance cannot explain this depletion on the basis of a short approach to the Sun and so this feature must be related to a non-chondritic composition of the progenitor asteroid. Future spectrophotometric observations of 1996 JG could confirm this and could also confirm that this asteroid is the progenitor of the NSC meteoroid stream.

References: [1] Jenniskens P., 2006, Meteor Showers and their Parent Comets. Cambridge University Press. [2] Madiedo J.M. and Trigo-Rodríguez J.M. (2008) *EMP* 102, 133-139. [3] Madiedo J.M. et al. (2010) Adv.in Astron, 2010, 1-5. [4] Ceplecha Z., 1987, Bull. Astron. Inst. Cz. 38, 222-234. [5] Madiedo J.M. (2014), Earth, Planets and Space, 66, 70. [6] Borovička J., Koten P., Spurny P., Boček J., Stork R. (2005), Icarus, 174, 15.