Composition of (1696) Nurmela: The second largest member of Baptistina Asteroid Family V. Reddy[1,2], J. A. Sanchez[2], W. F. Bottke[3], M. J. Gaffey[1], L. Le Corre[2], J. Masiero[4], and A. K. Mainzer[4], [1]Department of Space Studies, University of North Dakota, [2]Max-Planck Institute for Solar System Research, Germany. [3]SWRI, Boulder, Colorado, USA, [4]JPL, Caltech, California, USA.

Introduction: In 2007, [1] proposed a hypothesis suggesting that the impactor which caused the K/T mass extinction originated in the Baptistina Asteroid Family (BAF) in the main asteroid belt. BAF was created when its parent body experienced super catastrophic disruption approximately 160 million years ago. The K/T impactor was transported to near-Earth space via Yarkovsky effect and chaotic resonances and eventually collided with the 65 million years ago [1]. The fitted age of BAF depends on the density of the family members, which is what drives our desire to determine the taxonomy (compositional link).

The link between BAF and K/T impactor was made based on a fossilized meteorite presumed to be from the impacting asteroid that suggested a carbonaceous composition [1]. Colors of BAF suggested an X/C taxonomy, which included carbonaceous chondrite meteorites as possible analogs. Detail compositional analysis of several large BAF members including (298) Baptistina, the largest member of the family by [2,3] has shown that a majority of them have composition similar to the background Flora population. This indicated significant contamination of the BAF from members of Flora family and made Baptistina an interloper in its own family [2,3].

[4] suggested the possibility of (1696) Nurmela, the second largest member of the BAF, being a real representative of the original parent body. This was supported by the fact that Nurmela has an albedo of 0.125 [5], similar to several smaller BAF members that belong to X/C taxonomic class based on SDSS colors and near-IR observations [6]. If Nurmela is the largest remnant of the real BAF then its surface composition should be similar to X/C taxonomic class like the smaller BAF members as reported by [6]. In an effort to verify this new hypothesis we observed Nurmela with the NASA IRTF to determine its surface composition.

Observations and Data Reduction: Near-IR spectra of Nurmela were obtained on November 1, 2012, using the SpeX instrument on NASA IRTF in low-resolution prism mode [7]. The spectra were reduced using Spextools [8] provided by the IRTF. An average of 20 spectra of Nurmela is show in Fig. 1.

Analysis: Near-IR spectrum of Nurmela shows weak deep absorption bands (2-5 %) due to pyroxene similar to (298) Baptistina. The Band I center is at 0.98±0.01 μm and the Band II at 2.02±0.04 μm with a band area ratio (BAR) of 0.57±0.05. The asteroid falls in the S(IV) region of the Gaffey S-asteroid subtype plot [9] suggesting a composition similar to an ordinary chondrite (Fig. 2). [10] divided the S(IV) region into three zones for each of the three ordinary chondrite groups (H, L, LL). The dotted line is the olivine-orthopyroxene mixing line. Nurmela plots on the border between L and LL chondrites just below (298) Baptistina, which is clearly in the LL chondrite zone.

Using equations from [10] we calculated the ferrous iron abundance in olivine and pyroxene for Nurmela and Baptistina. Figure 3 shows ferrous iron abundance (mol %) in forsterite (Fa) and ferrosilite (Fs) for H, L and LL chondrites from [11]. We plotted Nurmela and Baptistina on the same plot and they both have olivine and pyroxene chemistries similar to LL chondrites. Nurmela is slightly more iron poor than Baptistina with $Fs_{22\pm1.4}$ and $Fa_{27\pm1.3}$.

Implications: Based on the pyroxene absorption bands, and LL chondrite type pyroxene-olivine chemistries, (1696) Nurmela does not belong to X/C taxonomic type. This supports the hypothesis proposed by [2,3,6) that largest members of the BAF are interlopers, probably from the Flora family. The similarity in composition of (298) Baptistina and (1696) Nurmela opens up two possibilities, a) these are both part of the BAF but the family is not X/C class, b) they both are interlopers from Flora family and not part of BAF.

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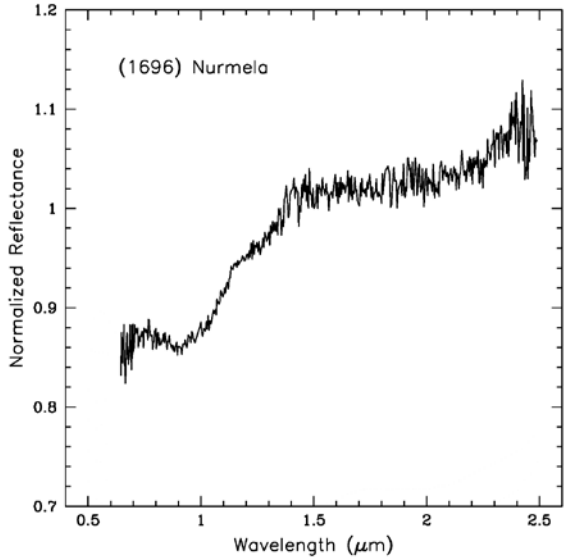

Figure 1. Near infrared spectrum of (1696) Nurmela obtained using the SpeX instrument on NASA IRTF.

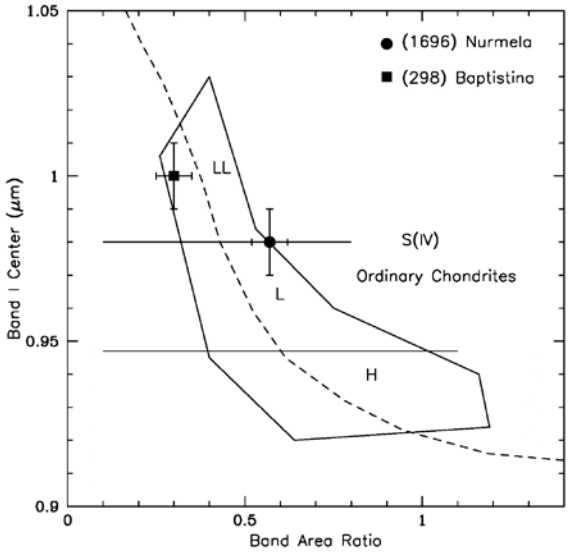

Figure 2. Band I center vs. BAR plot with the S(IV) region of the Gaffey S-asteroid subtypes. The dotted line is the olivine-orthopyroxene mixing line. Nurmela plots between L and LL chondrite zones of the S(IV) region.

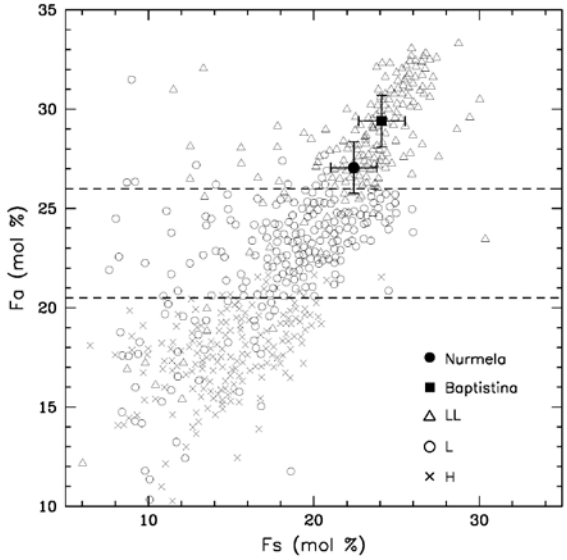

Figure 3. Fayalite (Olivine) vs. ferrosilite (pyroxene) plot from [11] showing ordinary chondrites. Olivine and pyroxene chemistries of Baptistina and Nurmela calculated using equations from [10]. Both objects plot in the LL chondrite region of the plot.