A MODEL OF INVESTIGATION OF THE SPECTRAL PROPERTIES OF V-TYPE ASTEROIDS: M. Angrisani[1], E. Palomba[2], A. Longobardo[3], A. Raponi[4], F. Dirri[5], C. Gisellu[6] ; [1]INAF-IAPS Rome, Via Fosso del Cavaliere ,100 Rome, (marianna.angrisani@inaf.it), [2]INAF-IAPS Rome (ernesto.palomba@inaf.it), [3]INAF-IAPS Rome (andrea.longobardo@inaf.it), [4]INAF-IAPS Rome (andrea.raponi@inaf.it), [5]INAF-IAPS Rome (fabrizio.dirri@inaf.it), [6]INAF-IAPS Rome (chiara.gisellu@inaf.it)

Introduction: V-type asteroids have a reflectance spectrum very similar to howardite-Eucrite-Diogenite meteorites (HED) and Vesta, with absorption bands centered at approximately 0.9 and 1.9 µm (hereafter called band I and band II) , and ascribed to pyroxenes. In this work, we present a new approach of analysis to investigate the composition and the regolith grain size of 76 V-type asteroids, through a combination of spectroscopic analysis of their VIS-NIR (0.7-0.8 µm to 2.5 µm) normalized reflectance spectra of and Hapke Radiative Transfer Model (hereafter Hapke RTM). Using band analysis techniques on HED and on V-type asteroids, we estimated the grain size range of the regolith. Then, we used the spectroscopic results as constraints in the Hapke RTM for a more accurate guess of grain size and mineralogy. It is also foreseen to test the genetic linkages between V-type asteroids, HED meteorites and Vesta.

Data and Methods: V-type asteroids spectra were obtained from SpeX ground based observations and are available on the Planetary Data System (PDS). We divided them in two datasets. The first group was from [1] and the second was from [2, 3, 4].

Since V-type asteroids are supposed to be the parent object of HED [5], in this work we compare the results obtained from V-type asteroid with HED meteorites (with size intervals known) used in [6], whose spectra are available on the NASA Reflectance Experiment LABoratory (RELAB) database at Brown University.

To extract the spectral parameters (band center, band depth, half width half maximum, e.g. BC, BD, HWHM) we applied the definitions of [6,7]. However, to better characterize the spectral parameters of each band, a spectrum should have simultaneously visible and near IR spectra. While this occurs on HED laboratory spectra, asteroids spectral data start from ≈0.8 µm and therefore do not cover the entire Band I spectra, making the calculation of the corresponding band descriptors difficult. For this reason, BCI (0.9 µm) is defined 7 nm long-ward of band minimum [8], whereas BCII (1.9 µm) is the band minimum after the spectral continuum removal [6,7].

The considered version of Hapke RTM is presented in [9]. The used end-members in the Hapke retrieval are clinopyroxene, orthopyroxene, plagioclase, olivine, troilite [10] and a darkening agent (a carbonaceous chondrite e.g. Murchison). Because V-type asteroids likely derive from Vesta, we cannot exclude the presence of chondrite carbonaceous material from dark area of Vesta [6]. We also assume that the scattering is isotropic and no backscattering is considered.

Through the scatterplot analysis (BCI versus BCII) we observed that the asteroids have the same mineralogy of HED and a global upper limit of grain size of 125 µm (from BDI versus BDII and BDII versus HWHM band I scatterplot). Then, the initial Hapke retrieval constrains are a grain size range of 1-125 µm and the main endmembers of HED and Murchison spectra. However, these could give a possible degeneration on the creation of synthetic spectra. This could give an estimation of grain size and of modal abundance that counterbalance one each other. However, using BDI versus BDII scatterplot and HWHM band I versus BDII scatterplot, a narrow range of grain size can be extrapolated for each asteroids.

Nevertheless, since the spectral data of first group of V-type spectra are in range ≈0.8-2.4 µm, possible errors on the spectral parameters (band depth and half width half maximum) of band I could arise. Therefore, for this dataset, we use the initial Hapke model constrains while, for the second dataset, which have spectral data in range ≈0.7-2.4 µm, we can make sure that the spectral parameters of band I could be less affected by error. For the latter dataset, we could use a narrow range of grain size on the research of synthetic spectra from Hapke retrieval and reduce the possible degeneration produced by the model. In particular, the grain size range selected is defined by the two lines closest to the location of asteroids in the BDI versus BDII scatterplot (Figure 1) and HWHM band I versus BDII scatterplot (Figure 2) scatterplots. Then, the Hapke model is applied to infer the modal abundance mineralogy and a more accurate grain size regolith for each asteroid.

Results and Discussion: From this analysis, the linkages between V-type asteroids and HED meteorites and Vesta is confirmed: the asteroids have a mineralogy similar to HED meteorites and a regolith mean grain size of ≈25 µm. Olivine-rich asteroids and contaminations of darkening agent like carbonaceous chondrites are not found. The lack of significant olivine-rich asteroids detection could be due to the absence of olivine enrichment in the Rheasilvia ejecta

[11,12,13]. On the other hand, the lack of darkening agent (as carbonaceous materials) could be an indicator of the time of formation of V-type asteroids. Probably, they formed before the possible materials delivered by low-velocity impacts on Vesta from the primitive asteroids [6].

As a result, the developed procedure could be employed to explore the mineralogy and the regolith grain size of V-type asteroids in a more precise manner (Fig.1 and Fig. 2), especially for those asteroids whose spectral data cover the entire range of VIS-NIR. , using a narrow range of grain size derived as results from scatterplot analysis, it could reduce the possible degeneration in the research of synthetic spectra.

In conclusion, this procedure (combination of spectroscopic analysis and Hapke RTM) could be a starting point to develop a new automatic analysis method, which represent an opportunity to research parent body of HED from V-type asteroids reflectance spectra features.

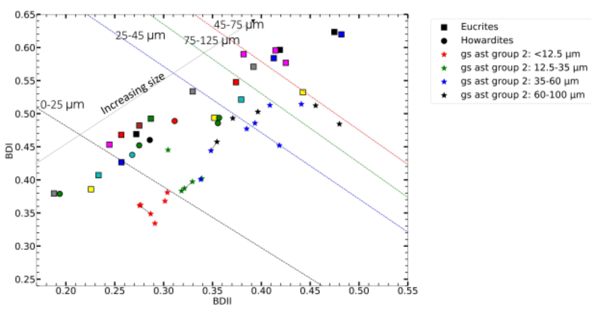

Fig.1: Band Depth I versus Band Depth II scatterplot for HED (squares, circles) and asteroids group 2 (stars). The lines stand for the median of cluster of HED grain size of 0-25, 25-45, 45-75, 75-125 µm. The asteroids (stars) are coloured basing on the grain size results from Hapke model. Multiple observations of asteroids are linked by a line. For the entire legend see [14].

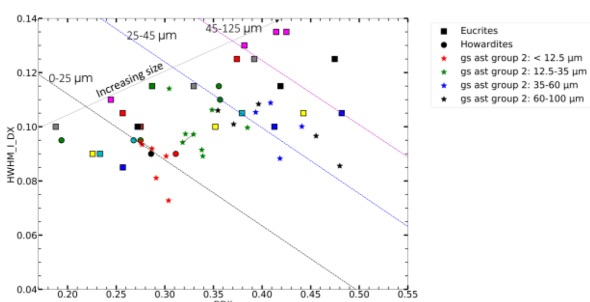

Fig.2: Half width half maximum I dx versus Band Depth II scatterplot for HED (squares, circles) and asteroids group 2 (stars). The lines stand for the median of cluster of HED grain size of 0-25, 25-45, 45-125 µm. The asteroids (stars) are coloured basing on the grain size results from Hapke model. Multiple observations of asteroids are linked by a line. For the entire legend see [14].

Acknowledgments: The V-type spectra are download from Planetary Data System (PDS):

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[2,3,4] Hardersen,P.S., Hardersen IRTF Asteroid NIR Reflectance Spectra V1.0. EAR-A-I0046-3-HARDERSENSPEC-V1.0. NASA Planetary Data System, 2016.

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