

**SEARCHING FOR FAINT ABSORPTION BANDS IN VESTOID REFLECTANCE SPECTRA BY MEANS OF OPTIMAL SMOOTHING ALGORITHM.** L. Golubeva<sup>1</sup>, D. Shestopalov<sup>1</sup>, and L. McFadden<sup>2</sup>. <sup>1</sup>Shemakha Astrophysical Observatory, Shemakha, Azerbaijan 373243 ([land@azdata.net](mailto:land@azdata.net)). <sup>2</sup>Department of Astronomy, University of Maryland, College Park, MD 20742-2421 ([mcfadden@astro.umd.edu](mailto:mcfadden@astro.umd.edu))

Reflectance spectra of the vestoids are quite suitable for testing the smoothing algorithm proposed in [1]. The vestoid spectra obtained within the framework of SMASS1 [2] have a good resolution, approximately 0.1 nm per channel. Interpretation based on the properties of the absorption bands near 900 and 1900 nm [3, 4, 5] leads to relatively simple mineral composition of asteroid surfaces. On the whole the vestoid surface material is orthopyroxenes and, probably, small portion of olivines (so that  $\text{opx/ol} \gg 1$ ) [5]. Howardites, eucrites and diogenites (HED) are good analogues of the vestoid surfaces [4, 5]. And, last but not least, that pyroxene spectra are well investigated in the visible range [6 and references therein].

The vestoid spectra as well as other asteroid CCD-spectra contain the high-frequency oscillations of the reflectance coefficients. In the visual spectral range these oscillations carry information about the spin-forbidden absorption bands which are associated with cations of the transition group elements. To separate these faint absorption bands from random noise we use the optimal smoothing of a noisy spectrum by the method described in [1].

The initial and the smoothed spectra of some vestoids are shown in Fig.1. The optimal number of points in the running box for each asteroid spectrum is indicated in the legend. The spectral range of 460 - 580 nm is free from strong telluric bands, therefore we have the reason to think that the faint absorption bands, which are well seen in the smoothed spectra, arise due to the surface composition of the asteroids.

To define a band status in the smoothed spectrum we calculated the ratio ( $\eta$ ) of summary area of the noises around the band contour to the equivalent width of the band. If  $\eta \lesssim 1$  then the band status is defined as "yes" or (+); if  $\eta > 1$  but the band is still seen in the spectrum, the status is "may be" or ( $\pm$ ). Thus the spectral position of the faint absorption bands and their status are the following: near 480 nm ( $\pm$ ) for 3155 Lee; 490nm ( $\pm$ ) for 1906 Naef; 505 nm ( $\pm$ ) for 2011 Veteraniya and (+) for the others; 530 nm (+) for 2011 Veterania; 550 nm ( $\pm$ ) for 2011 Veterania and (+) for the others.

Let us compare the obtained results with pyroxene spectral data. According to [6] the spin-forbidden absorption bands at 470-480 and 550 nm reveal themselves in the spectra of low-ferrous pyroxenes due to  $\text{Fe}^{2+}$  cations which are situated in

the M2 structural site. In the spectra of Fe-rich ortho- and clinopyroxenes (nearly all  $\text{Fe}^{2+}$  are in the M1 site) the specified bands are absent, but new absorption bands at 460, 490 and 525 nm are present. The absorption band at 505 nm is associated with  $\text{Fe}^{2+}$ , situated both in the M2 and in the M1 sites [6,7]. The wavelength position and shape of the band depend on pyroxene chemical composition [7,8].

The results [6, 7, 8] were obtained for individual pyroxene crystals with the help of the microspectrometers and depict some ideal picture. Reflectance spectrometry has to deal with macroscopic surfaces and gives some general information about collective interaction of light with a great number of mineral crystals, whose physical and chemical properties are not strictly equal. Fig.2 shows the examples of the achondrite reflectance spectra from our meteorite spectral set [9]. The spectra were measured for samples without visible signs of terrestrial weathering. Spectrum of the aubrite (powder) does not contain well-defined absorption bands with the exception of the weak depression near 480 nm. Obviously ferric oxide content is very low in the given sample of the enstatite meteorite. Spectra of the HED (fragments) show a pair of bands near 505 and 550 nm as well as the low intensity bands near 530 and 480 nm (Yurtuk) and near 490 nm (Juvinas, Shalka). Hence some portion of  $\text{Fe}^{2+}$  in these low-calcium pyroxenes is still located in the M1 site.

Comparing the spectral curves in Fig.1 and Fig.2 we note good agreement of the absorption band positions in asteroid and meteorite spectra, and conclude that the absorption bands in the vestoid spectra belong to  $\text{Fe}^{2+}$  in their surface pyroxenes. Indeed, the spectra of 1933 Tinchen and 3657 Ermolova have the pair of the bands near 505 and 550 nm that is typical for spectra of low-calcium orthopyroxenes of the HED. We see the absorption band near 530 nm in the spectrum of 2011 Veterania. The spectra of 1906 Naef, 3155 Lee and 1929 Kolaa show the shallow and broad depression with minimum near 540 - 550 nm. One may suppose that wings of the faint 530- and 550 nm bands are blended, and we observe common contour of these bands.

So, the conclusion about the vestoid surface compositions obtained here and by using the NIR spectra [3, 4, 5] are in a good agreement with each other. Therefore we think that the processing of noisy

asteroid spectra by the optimal smoothing algorithm allows extracting some additional information, hidden by the noises before and, consequently, opening new possibilities of the analysis of the asteroid CCD-spectra from SMASS1.

**References:** [1] Shestopalov D. I. et al, (2005) *This volume*. [2] Xu Sh. et al, (1995) *Icarus*, 115, 1 - 35. [3] Hiroi T. et al, (1995) *Icarus*, 115, 374 - 386. [4] Burbine T.H. et al, (2001) *Meteoritics & Planet. Sci.*, 36 761 -781. [5] Duffard R. et al, (2004) *Icarus*, 171, 120 - 132. [6] Khomenko V.M., Platonov A. N. (1987) *Rock-forming Pyroxenes: Optical Spectra, Coloration, Pleochroism*, “Naukova Dumka”, Kiev. [7] Hazen R. M. et al, (1978) *Proc.9<sup>th</sup> Lunar Planet Sci.Conf.*, 2919 - 2934. [8] Shestopalov D. I.. et al, (1991) *Sol. Sys. Res.*, 25, 442 - 452. [9] Golubeva L.F. (1990) *Thesis*, Main Astronomical Observatory, Kiev.

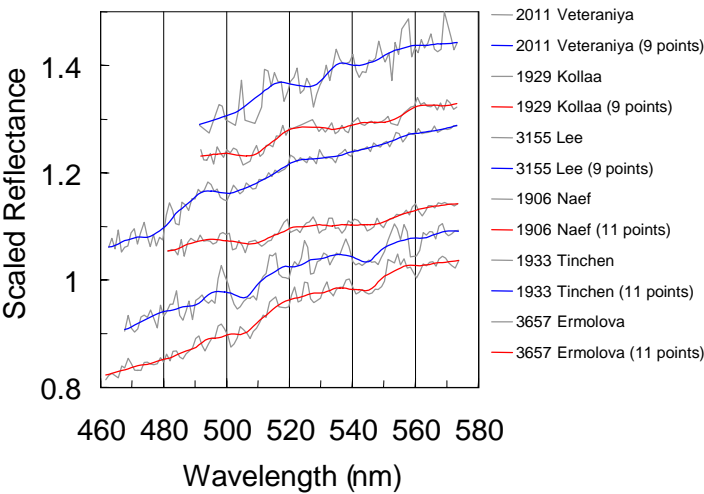


Fig.1. The observed [2] and the smoothed spectra of some vestoids. Curves are shifted for clarity.

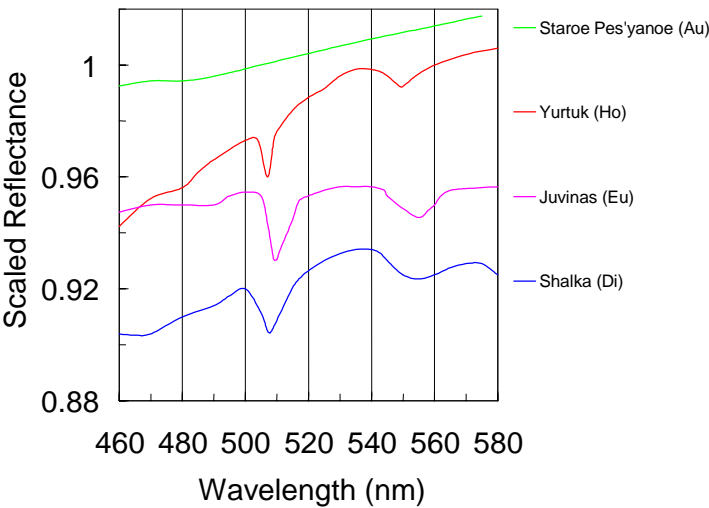


Fig.2. Spectra of some achondrites. Curves are shifted for clarity.