DIOGENITE-LIKE FEATURES IN THE SPITZER IRS (5–35μm) SPECTRUM OF 956 ELISA.

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We report preliminary results from the Spitzer IRS (Infrared Spectrograph) observations of the V-type asteroid 956 Elisa. Elisa was observed as part of a campaign to measure the 5.2–38 micron spectra of small basaltic asteroids with the Spitzer IRS. Targets include members of the dynamical family of the unique large differentiated asteroid 4 Vesta ("Vestoids"), several outer-main-belt basaltic asteroids whose orbits exclude them from originating on 4 Vesta, and the basaltic near-Earth asteroid 4055 Magellan.

4 Vesta's dynamical family of small basaltic asteroids is believed to be the proximate source of the HED meteorites, the majority of which are thought to have their ultimate origin on Vesta itself [1, 2] . Hubble imaging of Vesta [3] has revealed an impact basin large enough (D $\approx$ 460 km) to be the source of all known Vestoids. Spectral studies of Vestoids in the visible and near-IR have characterized their olivine and pyroxene compositions and revealed significant differences between HED and Vestoid populations. For example, about 25% of HED meteorites are diogenites, although to date, observations of diogenite-like near-IR spectra among Vestoids have been very rare; whereas a number of vestoids [e.g. 2579 Spartacus; 4] appear to have olivine-rich compositions not represented among meteorites. Similar NIR features suggest regional olivine exposures on Vesta itself [5, 6].

Thermal Model Fitting: To model the thermal continuum of 956 Elisa (Fig. 1), we apply a variant of the Standard Thermal Model ("STM"; Lebofsky et al. 1986) to the IRS emission spectra of the asteroids. In each of our fits, just two free parameters are allowed to float: the radius of the asteroid and its maximum (subsolar-point) temperature, $T_{ss} \cong (((1\text{-albedo})(\text{insolation})) / (\eta\epsilon\sigma))^{0.25}$ where σ is the Stefan-Boltzmann constant, ϵ is the effective emissivity, and η is the "beaming parameter", representing a combination of thermophysical properties of the surface (e.g. thermal inertia) and surface roughness.

The preliminary STM fit to the 5–35 μm spectrum of 956 Elisa gives a radius of 5.4 $\pm$ 0.3 km and a subsolar-point temperature of 282.2 $\pm$ 0.5 K. This temperature corresonds to $\eta \cong 1.06 \pm 0.02$, which is substantially higher than the $\eta \cong 0.756$ characterisic of large main-belt asteroids [7]. Unlike 4 Vesta and other large asteroids, therefore, 956 Elisa has significant thermal inertia in its surface layer.

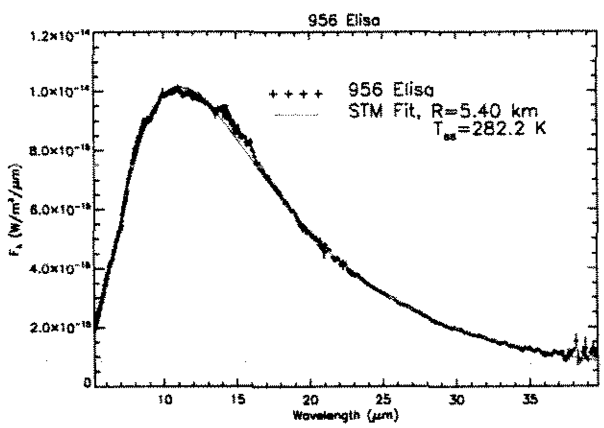

Figure 1: Spitzer IRS spectrum of 956 Elisa with STM fit overplotted.

Preliminary Assessment of Spectral Features: The spectral emissivity variation of the asteroid can then be found by dividing the asteroid's spectrum by the thermal continuum. The IRS emissivity spectrum of 956 Elisa is illustrated in Fig. 2. The wavelength of the Christiansen feature (emissivity maximum just shortward of 9 μm), the positions and shapes of the narrow maxima (10 μm, 11 μm) within the broad 9–14 μm silicate band, and the 19–20 μm minimum are similar to features found in the laboratory spectra of diogenites [8] and of orthopyroxenes similar in composition to diogenitic orthopyroxene [9]. Howardites, which contain diogenitic clasts, also display these features, albeit at substantially lower spectral contrast (Fig. 3).

Several features of the IRS spectrum have yet to be fully investigated. It remains uncertain whether the 14.5 μm peak is real or an instance of the IRS "teardrop" artifact known to occur sporadically at this wavelength.

Comparison with Near-IR Spectra: The near-IR spectum of 956 Elisa is not consistent with a predominantly diogenitic global surface composition. The temperature-corrected band centers at 0.9252 and 1.9592 μm correspond to Fs and Wo molar contents of 32 $\pm$ 3 and 7 $\pm$ 1 respectively, placing the NIR spectrum overall within the howardite range. However, because of the very great variation in mid-IR spectral contrast (Fig. 3) with com-

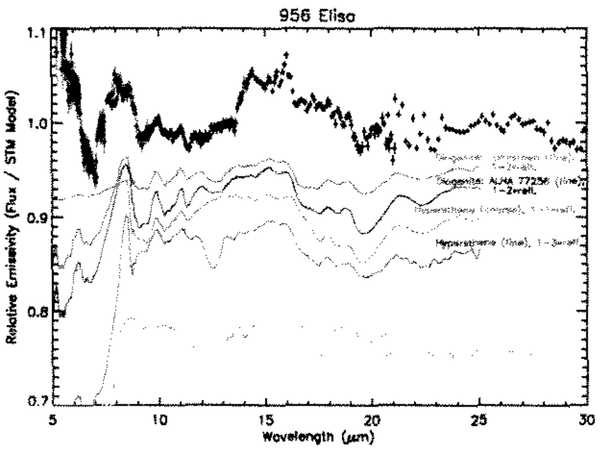

Figure 2: Spitzer IRS spectrum of 956 Elisa in emissivity, with laboratory spectra of HED meteorites and relevant minerals [8, 9]. In this plot, the spectral contrast of the laboratory spectra has been varied in order to make the wavelengths of features apparent. (See Fig. 3 for the relative spectral contrasts of the laboratory spectra.) "Coarse" indicates lab samples of 74–250 μm particle size; "Fine" describes samples of 0–75 μm particle size.

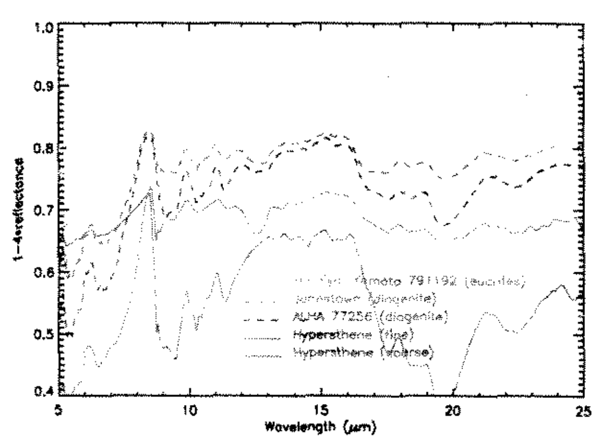

Figure 3: Laboratory spectra of HED meteorites and a hypersthene similar to the orthopyroxenes that dominate the composition of diogenites [8, 9]. This plot illustrates the significant differences in the spectral contrast of the 8–14 and 16–24 micron features among samples. Spectral contrast is much greater in fine-grained diogenites than in fine-grained howardites or eucrites. Coarse-grained orthopyroxenes, represented here by a terrestrial sample of diogenite-like composition [the "hypersthene" (26.1% MgO, 1.3% CaO) of 9], have still stronger spectral features.

position and particle size, the mid-IR spectrum may still be dominated by diogenitic features even if the overall composition is not. The Opx-rich material may be coarse in grain size compared with the majority of the asteroid. Alternatively, it may be concentrated close to the subsolar point at the time of observation, as the warmest parts of the asteroid will be overrepresented in any thermal IR spectrum.

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References

[1] T. B. McCord, J. B. Adams, and T. V. Johnson. Asteroid Vesta: Spectral reflectivity and compositional implications. *Science*, 178:745–747, 1970.

[2] R. P. Binzel and S. Xu. Chips off of asteroid 4 Vesta - Evidence for the parent body of basaltic achondrite meteorites. *Science*, 260:186–191, April 1993.

[3] P. C. Thomas, R. P. Binzel, M. J. Gaffey, A. D. Storrs, E. N. Wells, and B. H. Zellner. Impact excavation on asteroid 4 Vesta: Hubble Space Telescope results. *Science*, 277: 1492–1495, 1997.

[4] T. H. Burbine, P. C. Buchanan, R. P. Binzel, S. J. Bus, T. Hiroi, J. L. Hinrichs, A. Meibom, and T. J. McCoy. Vesta, Vestoids, and the howardite, eucrite, diogenite group: Relationships and the origin of spectral differences. *Meteoritics & Planetary Science*, 36:761–781, June 2001.

[5] M. J. Gaffey. Surface Lithologic Heterogeneity of Asteroid 4 Vesta. *Icarus*, 127:130–157, May 1997.

[6] R. P. Binzel, M. J. Gaffey, P. C. Thomas, B. H. Zellner, A. D. Storrs, and E. N. Wells. Geologic Mapping of Vesta from 1994 Hubble Space Telescope Images. *Icarus*, 128: 95–103, July 1997. doi: 10.1006/icar.1997.5734.

[7] J. R. Spencer. A rough-surface thermophysical model for airless planets. *Icarus*, 83:27–38, January 1990. doi: 10. 1016/0019-1035(90)90004-S.

[8] J. W. Salisbury, D. M. D'Aria, and E. Jarosewich. Midinfrared (2.5-13.5 microns) reflectance spectra of powdered stony meteorites. *Icarus*, 92:280–297, August 1991.

[9] J. W. Salisbury, D. M. D'Aria, L. S. Walter, and N. Vergo. *Infrared (2.1- 25 micrometers) Spectra of Minerals*. Johns Hopkins University Press, 1991.