THE SURFACE TEXTURE OF VESTA. T. LeBertre and B. Zellner, Lunar and Planetary Laboratory, Univ. Arizona, Tucson 85721.

The minor planet 4 Vesta shows a reflection spectrum unique among the larger asteroids, and appears to be the only good candidate in the solar system for the parent body of the basaltic achondrites (1,2,3,4). Optical reflection polarimetry can be quite sensitive to surface texture and particle size as well as albedo (5,6). Thus we have measured polarization-phase curves for various grain-size fractions of eucrites, howardites, and diogenites for comparison with the telescopic observations of Vesta.

Figures 1 and 2 illustrate the relevant angles at the laboratory goniometer and on the surface of a spherical planet. The laboratory techniques have been described by Zellner (7). For the coarser preparations of achondrites we find that the polarization depends on the angles i, ε, and τ or ϕ individually at fixed phase angle α. It is then necessary to sample representative points on the illuminated hemisphere to reconstruct the global polarization as a function of phase.

Figure 3 illustrates the telescopic data for Vesta. The polarization is negative out to inversion angle $\alpha_o = 22^o$, with maximum depth of the negative branch $P_{min} = 0.6\%$. The visual geometric albedo of the planet is 0.23 according to thermal radiometry (8) or 0.22 by the polarimetric method (9), and the diameter is near 550 km.

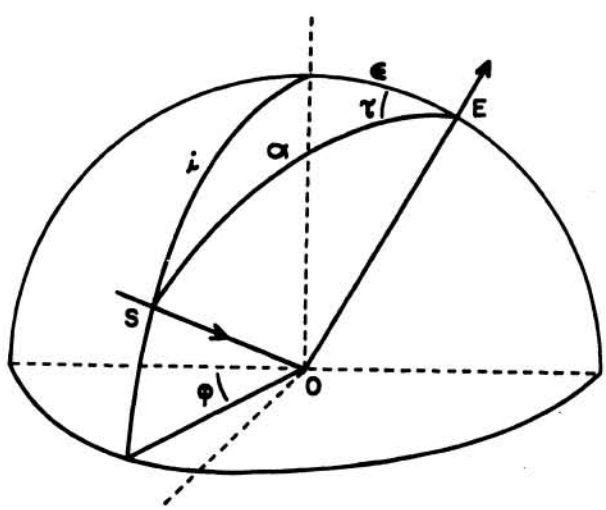

Fig. 1. Angles of incidence i, emergence ε, azimuth ϕ, and phase α for a horizontal sample at point O. The lightsource is in direction S, and detector at direction E.

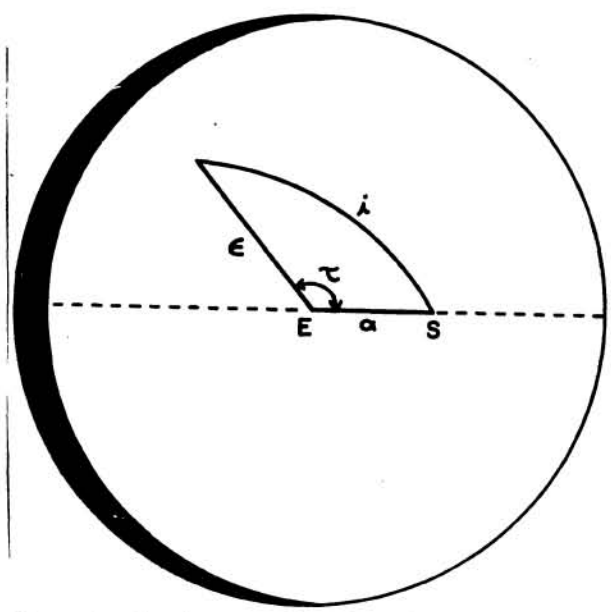

Fig. 2. Angles as in Fig. 1, projected on the apparent disk of a spherical body in space. S is the sub-solar point, and E the sub-earth point.

SURFACE TEXTURE OF VESTA

T. LeBertre

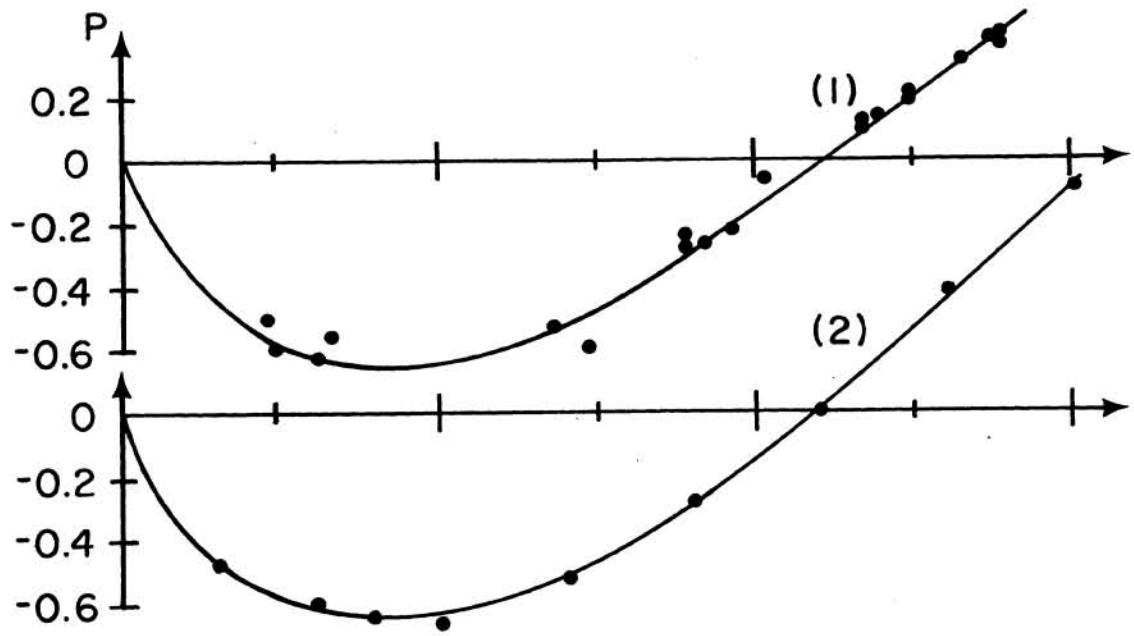

Fig. 3. Polarization-phase curve of Vesta (top) and a preparation of the eucrite Bereba consisting of a mixture of particle sizes with a substantial component of very fine dust (bottom).

We have measured samples of the howardite Pavlovka, the diogenites Shalka and Johnstown, and the eucrites Padvarninkai, Nobleborough, Bereba, and Moama. Discrete size fractions of grain diameter <37 μm, 37-74 μm, and >74 μm were prepared by sieving after hand crushing with a mortar and pestle. The process generates very little fine dust; a fourth sample consisting of fine adhesive dust with grain size 2-10 μm was produced by assiduous regrinding.

Size fractions <37 μm and the pure dust gave geometric albedos always too high, in the range 0.27 - 0.40. Samples 37-74 μm and >74 μm invariably gave the polarimetric P_{min} and inversion angle α_o too small. As illustrated in Fig. 3, we find a good fit for all the observed optical properties of Vesta with a preparation of Bereba consisting of a broad mixture of particle sizes together with enough fine dust to coat about half the surface area of the larger grains. Similar results could probably be obtained with any of the eucrites or howardites, except apparently for the cumulate Moama. The dust is needed to reproduce the polarimetric properties of Vesta, and the coarser grains to keep the albedo down. The upper limit on grain size is rather indeterminate in our work.

SURFACE TEXTURE OF VESTA

T. LeBertre

Thus we conclude that the known optical properties of Vesta can be explained by crushed basaltic achondrites with a substantial component of very fine dust. There is no need to invoke regolith darkening mechanisms and agglutinate formation as on the lunar surface. To the extent that comminution processes are independent of gravity and composition, similar conclusions will apply for other minor planets.

Photometrically, the samples best matching the polarimetric properties of Vesta obey the Minnaert reciprocity principle but not the Lommel-Seeliger law. At small phases the intensity along the photometric equator is constant on the sunward side and drops only slightly toward the terminator. The global geometric albedo and the value at the sub-earth point differ by not more than 5%, so that limb darkening is of no serious concern in computing the radiometric or polarimetric diameter. The microscale phase coefficient β is 0.021 magnitudes per degree; the larger value $\beta = 0.025$ observed telescopically for Vesta (10) is presumably a result of macroscopic roughness, which has no effect on the polarimetric or spectroscopic properties.

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