

EFFECTS OF MINERAL GRAIN SIZE AND PHYSICAL PARTICLE SIZE ON SPECTRAL REFLECTANCE OF BASALTS. R.B. Singer and P.L. Blake, Planetary Geosciences Div., Hawaii Inst. of Geophysics., Univ. of Hawaii, Honolulu, Hawaii 96822.

Introduction. Visible and near-IR reflectance spectra (0.4-2.6 $\mu$ m) for powdered basalts typically have a positive continuum slope, especially when olivine is present (Fig. 1) (eg. 1,2,3). We have found, however, that many fine-grained basalts have distinctive negative spectral slopes in the near-IR when observed as whole rocks (Fig. 2b-d). While this is not inconsistent with particle-size effects reported previously (4,5), our data are more detailed and show changes to the important Fe<sup>2+</sup> crystal-field absorptions of pyroxenes and olivine. These effects are of importance to remote sensing of planetary surfaces. We are therefore studying quantitatively the spectral consequences of both mineral grain size and physical particle size for basaltic assemblages.

Data Set. As part of a project at Kilauea volcano we have obtained laboratory reflectance data for a large number of tholeiite basalts. Most of this data is for fresh rock surfaces; selected samples have also been measured as powders. These rocks are mostly crystalline with little or no interstitial glass. Groundmass grain sizes range from a few to  $\sim$ 60 $\mu$ m. Most pyroxene occurs in the groundmass with plagioclase (labradorite) and  $\sim$ 5 modal % opaques. Olivine occurs as phenocrysts, varying from about 5 to 20 modal % and from 100  $\mu$ m to 3mm in size.

Mineral Grain Size. Some basaltic rock surfaces show characteristics similar to those observed for particulate samples: compare KDC42 powdered (Fig. 1a) with whole rock (Fig. 2a). In sharp contrast is the distinctive spectral behavior of whole rocks with similar reflectances for the 1- and 2- $\mu$ m band minima and low reflectance in between these two bands. To our knowledge basalt spectra of this type have not been previously reported. The whole rock spectrum of KDC36 (Fig. 2b) is somewhat intermediate between the two extremes. These differences are of special importance because low reflectance on the long-wavelength side of the pyroxene 1- $\mu$ m band is frequently interpreted as an indication of olivine (1,2,3). Of these rocks, KDC34 (Fig. 1d) contains substantial olivine ( $\sim$ 20%), while KDC06 (Fig. 1c) contains virtually none. While some of the observed variation in the 1.1-1.7 $\mu$ m region seems to be caused by olivine, the effect is different and less obvious than the "shoulder" normally associated with pyroxene-olivine mixtures (e.g. 1,2,3). The physical cause of this negatively-sloping spectrum is under continued study. We believe it is related to scattering differences caused by variation in grain size and distribution of groundmass minerals. This idea is supported by a comparison of Figs. 1 and 2, which show that spectra of fine-grained powders of samples KDC42 and KDC06 are far more similar than for the fresh rocks.

Physical Particle Size. Spectra for whole rocks and the larger particle size fractions show continuum and band depth characteristics significantly different from those observed for fine powders. Significant correlation exists for all rock specimens between physical particle size and continuum slope. Similar effects have been shown by Adams and Filice (4) and Ross et al. (5). To quantify these differences we have defined a number of parameters, shown schematically in Fig. 3. The upper continuum slope is defined by the straight line connecting reflectance maxima A and C. The lower continuum slope is defined by the straight line connecting band minima B and D (not necessarily band centers). Band depth is defined as (1-B/B') in the 1- $\mu$ m region and (1-D/D') in the 2- $\mu$ m region. Relationships between these two slopes and particle size is shown in Fig. 4. For both the upper and lower slope the trend is toward increasing slope for smaller particle sizes; the change is most pronounced for sizes less than about 355 $\mu$ m. The upper continuum slopes for whole rock spectra are similar to those for large particle sizes; this value is negative for many of the rock samples. In contrast, for particle sizes of 100-200 $\mu$ m (the size of powders typically studied), the upper slope is positive in all cases. The point is that laboratory spectra of powdered samples are not always directly comparable to remotely-sensed data.

There is also a correlation between physical particle size and the depths of pyroxene Fe<sup>2+</sup> crystal-field absorptions near 1 and 2 $\mu$ m (Fig. 5). For the samples studied there is a size for which 1- $\mu$ m band depth is a maximum; this occurs at varying particle sizes, but in every case less than about 300 $\mu$ m. Band depth decreases with particle size beyond this maximum. Note that band depth for whole rock samples does not always plot along the trend for the larger particle sizes, but frequently instead at some value nearer the maximum. Curves for the 2- $\mu$ m band do not show clear maxima; instead band depth generally increases with increased particle size, particularly for fine powders. The band depths for the whole rock spectra are similar to, but not direct extrapolations of, the data for the larger particle sizes.

References: 1) Adams, J.B. (1974) *JGR* **79**, 4329-4336. 2) Gaffey, M.J. (1976) *JGR* **81**, 905-920. 3) Singer, R.B. (1981) *JGR* **86**, 7967-7982. 4) Adams, J.B. and A.L. Filice (1967) *JGR* **72**, 5705-5715. 5) Ross et al. (1969) *Icarus* **11**, 46-54.

Spectral Reflectance of Basalts

Singer, R.B. and Blake, P.L.

