

OLIVINE-RICH ASTEROIDS, PALLASITIC OLIVINE AND OLIVINE-METAL MIXTURES: COMPARISONS OF REFLECTANCE SPECTRA; E.A. Cloutis, 4 Huntstrom Road N.E., Calgary, Alberta, Canada T2K 5W3

The recent acquisition of high resolution 0.3-2.6 μ m reflectance spectra of a number of olivine-rich asteroids [1,2] permits analysis of their surface compositions to be made on the basis of new and existing laboratory spectral data for pallasitic olivines [3] and olivine-metal mixtures [4,5]. Analysis of the spectral data for the latter has revealed a number of spectral parameters which can be used to constrain olivine and metal abundances, grain sizes and olivine compositions.

Pallasite Olivine Spectra. The 0.3-2.6 μ m reflectance spectra of <45 μ m size olivine separated from the Imilac pallasite (OLV201) (5 nm resolution, $i=0^\circ$, $e=15^\circ$) is shown along with those of some terrestrial olivines (Figure 1). Compositions of the samples are provided in Table 1. The OLV201 spectrum does not exhibit any marked dissimilarities from the terrestrial olivine spectra [3]. Consequently compositional differences between terrestrial and pallasitic olivines cannot be invoked to explain spectral differences between laboratory olivine-metal mixtures and olivine-rich asteroids [4].

Olivine-Metal Mixture Spectra. Increasing the amount of metal in an olivine-metal mixture results in a number of diagnostic spectral changes, mostly due to the red sloped spectrum of powdered meteoritic metal [6]. These include an increase in the 1.8-2.5 μ m slope (nearly flat for pure olivine), a decrease in the wavelength position of the intersection of a horizontal line tangent to the reflectance spectrum at the 0.5-0.7 μ m reflectance peak with the long wavelength wing of the absorption band near 1.05 μ m (horizontal tangent intercept- HTI) and an increase in the ratio of the reflectance at 1.8 μ m to that at the 0.5-0.7 μ m reflectance peak. Of these parameters, the HTI is the most diagnostic indicator of metal content because it is relatively insensitive to changes in olivine composition and particle size and small amounts of pyroxene [5]. The 2.5/1.8 μ m reflectance ratio is sensitive to small amounts of pyroxene and the 1.8/0.5-0.7 μ m reflectance ratio is sensitive to changes in both metal abundance and olivine chemistry [5]. Deconvolution of olivine-rich spectra is therefore best accomplished by measuring the HTI to constrain metal abundances (Figure 2) and the 1.8 μ m/band minimum reflectance ratio to constrain particle sizes (Figure 3).

Olivine-Rich Asteroid Spectra. The wavelength position of the HTI and 1.8 μ m/band minimum reflectance ratio for the olivine-rich asteroids 113 Amalthea, 246 Asporina, 354 Eleonora and 446 Aeternitas are shown in Figures 2 and 3, respectively, along with the values for terrestrial olivines [5], the Imilac olivine and Brenham pallasite olivine (<30 μ m grain size) [4]. No polarimetry data are available for these asteroids to constrain grain sizes; consequently the asteroid data have been plotted for a mean grain size of 150 μ m (see below). The HTI is relatively insensitive to grain size- a factor of 4 change in olivine and/or metal grain size would affect the metal abundance determination by at most 15% [5]. The asteroid HTI values clearly fall outside the range for terrestrial and pallasitic olivines and indicate surficial metal abundances of between ~30 and 40 wt% with 113 Amalthea and 446 Aeternitas being the most metal poor and metal rich, respectively.

The 1.8 μ m/band minimum reflectance ratios of the various samples are shown in Figure 3 as a function of grain size. The values for the olivine-rich asteroids (plotted at 150 μ m grain size) are consistent with either pure fine grained olivines or olivine-metal mixtures. The dashed lines indicate the extrapolated data for varying amounts of metal as a function of grain size. Since the HTI was used to constrain metal abundances, the data in Figure 3 indicate that the surfaces of these asteroids contain a spectrally significant amount of <150 μ m sized material. This size represents an upper limit since small amounts of pyroxene which may be present, as evidenced by shallow absorption bands in the 1.8-2.5 μ m regions of the asteroid spectra, will tend to increase this reflectance ratio [7].

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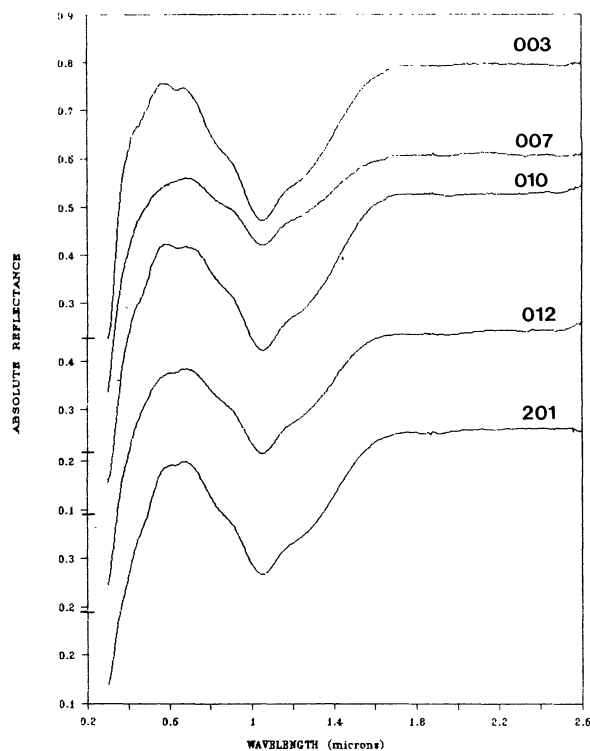


Figure 1. Reflectance spectra of <45 μ m size terrestrial olivines (003, 007, 010, 012) and Imilac pallasite olivine separate (201).

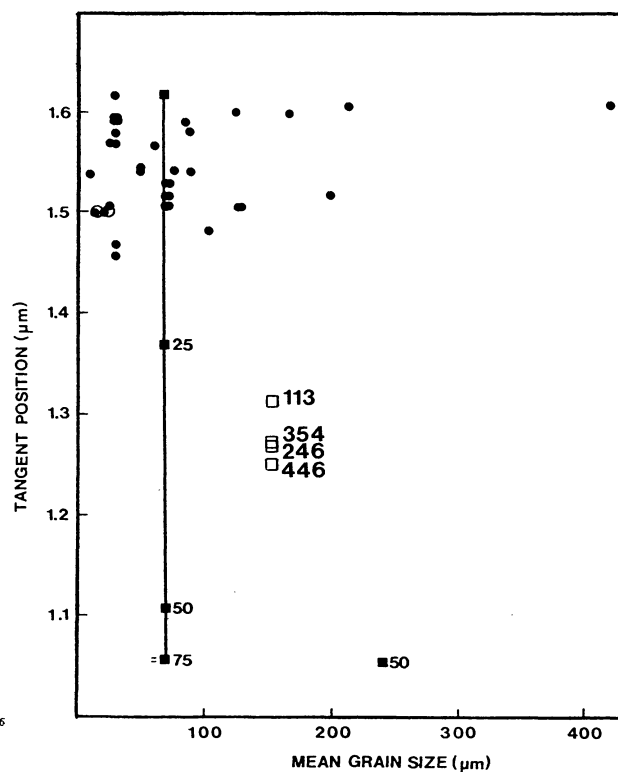


Figure 2. HTI (see text) versus particle size. Terrestrial olivines (filled circles), pallasitic olivines (open circles), olivine rich asteroids (open squares), olivine-metal mixtures (filled squares). Numbers indicate metal abundances in olivine-metal mixtures. Asteroids identified by their numeric prefixes.

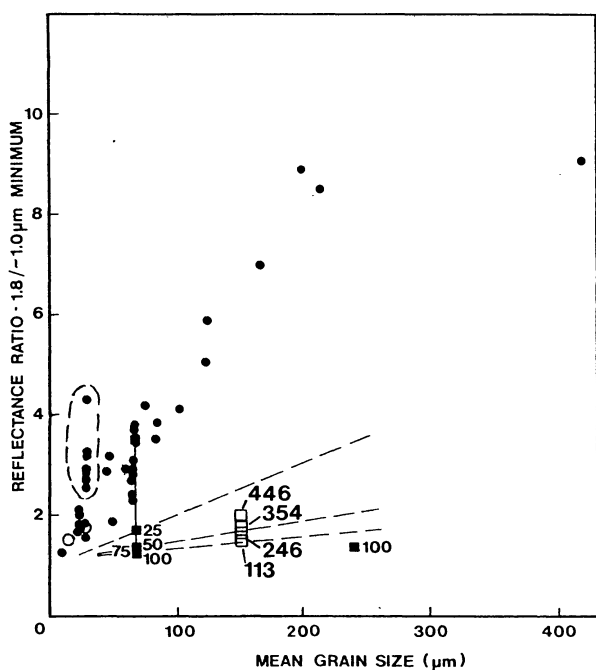


Figure 3. Reflectance ratio 1.8 μ m/band minimum versus grain size. Symbols are the same as in Figure 2.

Table 1. Compositions of Spectrally Characterized Olivines.

	003	007	010	012	201
SiO ₂	40.64	41.72	40.42	40.95	40.36
FeO	9.25	3.12	11.11	8.05	12.00
Fe ₂ O ₃	0.59	N.D.	N.D.	N.D.	N.D.
MgO	49.13	54.65	48.25	50.83	47.76
MnO	0.09	0.19	0.15	0.10	0.26
NiO	0.33	0.01	0.43	0.40	0.01
CaO	0.07	0.63	0.19	tr.	tr.
TiO ₂	0.00	0.00	tr.	0.00	tr.
Cr ₂ O ₃	0.01	tr.	0.13	0.00	0.02
CoO	0.04	0.01	0.04	0.06	0.03
Fo	90.4	96.9	88.5	91.8	87.6
Fa	9.6	3.1	11.5	8.2	12.4

tr.= trace (<0.01); N.D.= not determined