N92-10830

AN INFRARED REFLECTANCE STUDY OF LOW ALBEDO SURFACE CONSTITUENTS

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We are continuing our analysis of spectra obtained under the Planetary Astronomy Program and making laboratory spectral measurements for comparison with these telescopic observations. Our work has resulted in a chapter in the Atmospheres book (Lebofsky *et al.* 1989), in talks presented at the 1988 Asteroids II conference, 1988 and 1989 Meteoritical Society Meetings, Lunar Science Conference, American Chemical Society Meeting, the 1989 DPS, and at the 1991 Tucson Resources meeting. A chapter is now being written for the book that is coming out of the Resources meeting. Our results will also be presented at this year's Meteoritical Society and DPS meetings. Two papers have been published in *Icarus*, including a paper based of Tom Jones' dissertation. A chapter (from the ACS meeting) with M. J. Gaffey, L. Lebofsky T. Jones, and M. Nelson has just been accepted. Finally, a paper with Bell on the analysis of groundbased Deimos spectra is in preparation.

Our most recent work has been on the analysis of the spectra of low-albedo, outer belt and Trojan asteroids (Lebofsky *et al.* 1990). We summarize the results here.

Unaltered asteroids are thought to represent the raw materials available for terrestrial planet formation and so are important to our understanding of the origin and evolution of the Solar System. Compositional variation in the asteroid belt has long been interpreted as primordial, with asteroids becoming more volatile-rich with distance from the sun. Gradie and Tedesco (1982) showed that the asteroid compositional types varied systematically with heliocentric distance and inferred that the asteroids probably formed very close to their present locations in the asteroid belt. From their inferred composition, Gradie and Tedesco also concluded that the outer belt and Trojan asteroids were probably more "primitive" than the C-class asteroids which dominate the main belt. This interpretation was consistent with the earlier laboratory study of asteroid analogs by Gradie and Veverka (1980), who concluded that the low albedo D-class asteroids were probably "ultraprimitive" in composition, *i.e.,* composed largely of hydrated silicates and organic material. However, recent observations (Jones 1988, Jones *et al.* 1990, and Lebofsky *et al.* 1989, 1990) suggest that much of the surface mineralogy seems to be due to alteration events subsequent to formation rather than primordial composition. The distribution of water is the key to understanding the volatile content of the asteroid belt and controls much of the later alteration.

Observational testing of this idea relies on the exploitation of the 3-μm absorption feature in hydrated silicates—the only diagnostic spectral band evident in the dark, volatile-rich CI and CM meteorites (Lebofsky 1978). The existence of the band has demonstrated the presence of hydrated silicates on asteroids (Lebofsky *et al.* 1981, 1989, 1990; Jones 1988; Jones *et al.* 1989). An example of this feature is shown in the spectrum of the CI meteorite Orgueil (Fig. 1). The feature is characterized by a sharp reflectance drop at 2.7 μm, due to structural OH, and by an absorption due to H_2O that decreases slowly out to about 3.5 μm.

In our present observational program we are expanding our observations to include other low-albedo classes of asteroids, asteroids that range primarily from the middle and outer asteroid belt (>2.5 AU) to the Trojan region at 5.2 AU. Our prelimary results indicate that the outer belt and Trojan asteroids do not show features diagnostic of hydrated silicates and we conclude that these asteroids have not undergone the alteration processes that we see in the C-class asteroids. However, our observations show that only half of the C asteroids show the water of hydration band and in our most recent work, we have found a main-belt D that does show the band (Fig. 3, 4). This means that we must be very careful in assuming that the classes relate directly to mineralogy and that, in reality, there appear to be major differences in mineralogy within individual classes.

Before the start of our program very little high-resolution reflectance data existed on meteorites and asteroid analogs in the 3-μm spectral region. We now have a large dataset of laboratory spectra for comparison with our telescopic spectra (Jones 1988, Jones *et al.* 1990, 1991 in preparation). With these data in hand and results from our future efforts, we hope to understand better the composition of the primitive, relatively unaltered asteroids. Coupled with studies of meteorites and new theories of Solar System formation, this picture of asteroid composition may illuminate the materials and source regions for terrestrial planet formation.

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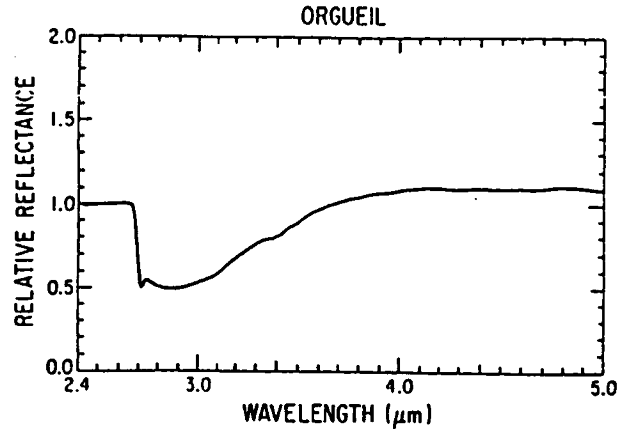

FIG. 1. A laboratory reflectance spectrum (2.4 to 5.0 μm) of the CI meteorite Orgueil. The spectrum is scaled to 1.0 at 2.5 μm (frome Jones 1988).

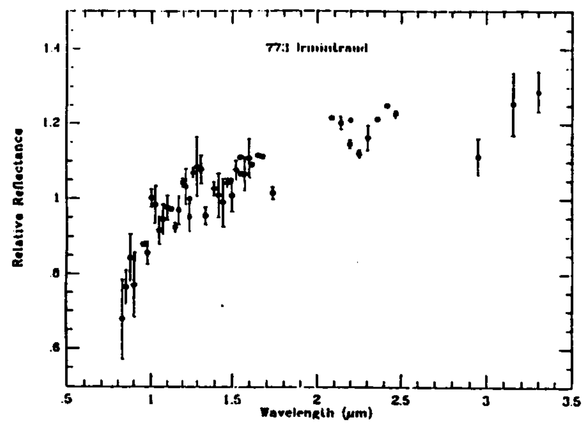

FIG. 2. Preliminary spectrum of asteroid 773 Irmintraud, a main belt D asteroid that appears to show the presence of a 3-μm water of hydration band.

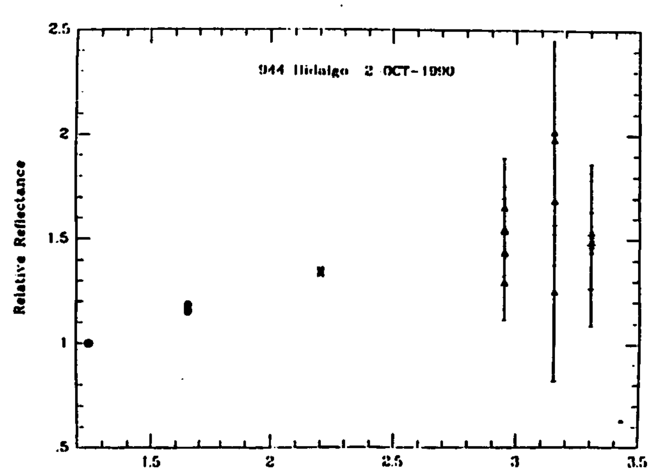

FIG. 3. Preliminary spectrum of asteroid 944 Hidalgo, an unusual D asteroid (on dynamic arguments, a possible extinct comet) that does not show the 3-μm band.