EFFECTS OF SMALL-SCALE SURFACE ROUGHNESS ON THE BIDIRECTIONAL REFLECTANCE SPECTRA OF NICKEL-IRON METEORITES. Daniel T. Britt and Carle M. Pieters, Department of Geological Sciences, Brown University, Providence, RI 02912.

Spectral reflectance studies have suggested that elemental iron is a major component of the surface mineralogy of M and S-type asteroids [1,2]. Both asteroid types exhibit a spectral red-slope (increasing reflectance with increasing wavelength) that has been interpreted as characteristic of the presence of large amounts of elemental iron. As asteroids become more frequent targets of remote sensing observations, both from ground-based telescopes and spacecraft, it is important to understand the bidirectional reflectance properties of metallic surfaces and how these surfaces relate to processes on metal-rich bodies.

The effect of small-scale (<1 mm) surface roughness and viewing geometry on the bidirectional reflectance of iron meteorites has been investigated using NASA's RELAB facility located at Brown University [3]. Samples of the Canyon Diablo and Gibeon [4] meteorites were polished with aluminum oxide and diamond abrasive grits to controlled surface roughnesses and checked with a reflected light microscope. After polishing, each sample was immediately washed in ethyl-alcohol and dried to prevent corrosion. At each roughness a series of spectra were taken at specular (i=0) and non-specular geometries. Spectra were also taken of several other complex metallic surfaces that are potential analogs for metallic regoliths resulting from asteroid processes such as cratering and particle size commutation. These included fresh filings of the Canyon Diablo meteorite (particle size range 30 microns to 1 mm) and two small craters in the Gibeon meteorite produced by experimental hyper-velocity impacts [5]. One crater was formed by a metal projectile, the other by a basalt projectile. Surface relief on both craters is in the range of 0.1 to 1 mm.

These measurements suggest that the spectra of metallic surfaces can be divided into three general groups that correspond to degree of surface roughness. Group I consists of surfaces rougher than 10 microns and smoother than 1 mm. Group II covers the roughness range from 10 microns to 0.3 microns. Finally, Group III consists of surfaces smoother than 0.3 microns.

**Group I (10 microns-1 mm):** A surface on the Canyon Diablo meteorite was polished with 400 grit aluminum oxide, producing relief in the range of 10-40 microns. The spectra of this sample is shown in figure 1 and is characterized by a classic iron red-slope exhibiting a featureless but steadily increasing reflectance. The albedo and spectral shape of this sample at both specular (i=0, e=30) and non-specular (i=10, e=10) geometries are similar, indicating that the surface is effectively a diffuse reflector. The spectra of the three complex metallic surfaces (filings, metal on metal crater, and basalt on metal crater) are also included in figure 1. Although the albedos of the three surfaces vary by a factor of 7, their spectral shapes (figure 2) are similar to the 400 grit surface. This suggests that for the roughness range of 10 microns to 1 mm the spectral properties of metallic surfaces are very similar, although albedos may differ substantially.

**Group II (0.3-10 microns):** Spectra of a sample of the Gibeon meteorite polished with 1200 grit aluminum oxide, producing relief in the range of 1-5 microns, are shown in figures 3 and 4. Spectra of this group are characterized by complex scattering processes. The specular component (figure 3) shows a maximum reflectance in the near infrared that decreases in wavelength position with increasing phase angle. The non-specular component (figure 4) flattens with increasing phase angle, progressively losing its characteristic red-slope. Samples of the Canyon Diablo meteorite polished to this roughness show similar results.

**Group III (<0.3 microns):** A sample of the Canyon Diablo meteorite was polished with diamond grit, producing surface relief less than 0.3 microns. At this roughness the surface is smoother than the wavelength of visible light and effectively a featureless mirror to light in the 0.5 to 1.8 micron range. Most of the incident light is reflected into the specular component with a minor contribution from the non-specular component. The spectra show a very bright and red-sloped specular reflection (figure 5) that flattens with increasing wavelength. The non-specular component, on the other hand, is dark and flat, showing none of iron's characteristic red-slope (figure 6).

**Conclusions:** Surfaces in the 10 micron to 1 mm roughness range are effectively diffuse reflectors, producing bidirectional reflectance spectra that are similar to each other and to published M-type asteroid [1] and directional-hemispherical (diffuse) iron meteorite [6] spectra. Smoother surfaces produce complex scattering behavior and the separation of the specular and non-specular components into distinctly different spectral types. Natural metallic asteroidal surfaces are probably best modeled by surfaces rougher than 10 microns.

SPECTRA OF IRON METEORITES
Britt, D.T. and Pieters, C.M.

Figure 1: Bidirectional spectra of Group I "rough" metallic surfaces. Viewing geometry is expressed i/e. (Halon Standard)

Figure 2: Bidirectional spectra of Group I surfaces scaled to 1.0 at 0.56 microns. (Halon Standard)

Figure 3: Bidirectional spectra of Group II moderately smooth surface. Specular reflectance (i=e) of Gibeon meteorite. Angle of incidence is indicated for each spectra. (Halon Standard)

Figure 4: Bidirectional spectra of Group II surface. Non-specular reflectance (i#e) of Gibeon meteorite. The spectral shape becomes flatter with increasing phase angle. (Halon Standard)

Figure 5: Bidirectional spectra of Group III smooth surface. Specular reflectance (i=e) of Canyon Diablo meteorite. (Calibrated Aluminum Mirror Standard)

Figure 6: Bidirectional spectra of Group III smooth surface. Non-specular reflectance (i#e) of Canyon Diablo meteorite. (Halon Standard)