REFLECTANCE SPECTRA OF MESOSIDERITES: IMPLICATIONS FOR ASTEROID 4 VESTA.

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Introduction: Mesosiderites are mixtures of subequal proportions of silicates and FeNi metal [1,2]. Silicates commonly occur as mineral fragments and lithic clasts and exist in a matrix composed of FeNi metal. The mesosiderite silicate fraction bears a close resemblance to the HED (howardite, eucrite, and diogenite) suite of basaltic and gabbroic achondrites, commonly thought to be from the asteroid 4 Vesta [3]. Mineral and lithic clasts in the mesosiderites are predominantly composed of pyroxene (either magnesian orthopyroxene or exsolved mixtures of augite and pigeonite) and Ca-rich plagioclase [1,2]. In contrast to HED meteorites, however, mesosiderite silicates also include significant proportions (generally <10 vol%) of olivine as individual mineral fragments and dunitic clasts [1,2]. FeNi metal that makes up the matrix of mesosiderites is most similar to that found in IIIAB iron meteorites [1].

Mesosiderites appear to be a mixture of material from the crust and core of a differentiated body and contain very little material from the region in-between, the olivine-rich mantle. As a consequence, the origin of the mesosiderites has always been somewhat controversial. One theory for the origin of the mesosiderites is that they resulted from the impact of the molten metallic core of an asteroid iron core with the crust of a differentiated body [5,6]. Haack et al. [6] date the impact as occurring ~4.4 Gy ago. Using Mn and Cr isotopes, Wadhwa et al. [2] find a time difference of ~2 Ma in the establishment of the mantle source reservoirs on the HED and mesosiderite parent bodies, which they argue implies distinct but compositionally similar parent bodies.

Recently, Greenwood et al. [7] presented high-precision oxygen isotope measurements of mesosiderites and compared their values to HEDs. They found that the silicate fraction of the mesosiderites and HEDs are isotopically identical. This is consistent with HEDs and mesosiderites being derived from the same parent body, or parent bodies, with virtually identical oxygen isotopic compositions [7]. Reflectance spectra of the HEDs in the visible and near-infrared are similar to the spectra of the ~500-km diameter asteroid 4 Vesta [3,8]; however, Vesta is usually thought to be the parent body of the HEDs but not the source of the mesosiderites. HEDs do not usually contain significant abundance of metallic iron as would be expected if a "large" metallic iron body had impacted into the surface layers of the HED-parent body.

Rosing and Haack [9] have identified the first mesosiderite-clast in a howardite (Dar al Gani 779). The clast is a centimeter-sized metal-rich inclusion with fragments of olivine, anorthite, and orthopyroxene plus minor amounts of chromite, tridymite, and troilite. The presence of this metal-rich clast could imply that mesosiderites and HEDs originate on the same parent body. Yamaguchi et al. [10] have also found that the platinum group element (PGE) abundances of a number of eucrites are similar to the PGE abundances in mesosiderites and IIIAB irons. They argue that this observation implies the same parent body for the HEDs and mesosiderites.

Vesta is currently one of the target objects for the upcoming Dawn mission [11], which will map this asteroid with both a visible-IR mapping spectrometer and a gamma-ray and neutron spectrometer. Even though a number of spectral studies have been done on HEDs [12,13], very few spectral measurements have previously been done on mesosiderites [12]. To determine their spectral characteristics, we have done a spectral survey of mesosiderites.

Data: Reflectance spectra (Figure 1) in the visible and near-infrared were obtained at RELAB on four mesosiderite samples from the Natural History Museum, London. The mesosiderites included Estherville, Lamont, Pinnaroo, and Vaca Muerta. Only Estherville is an observed fall. The silicate fractions of the samples were ground to a powder, but the samples were not sieved. Beside the powdered samples, a large metallic grain in Pinnaroo was also measured spectrally.

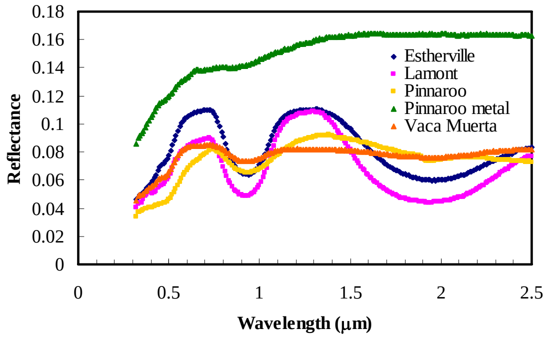

Figure 1. Reflectance spectra of mesosiderites.

The reflectance spectra of Estherville and Lamont are consistent with pyroxene-dominated assemblages since they have the distinctive pyroxene absorption features that are centered near 0.9 µm (Band I) and 1.9 µm (Band II). The spectra of Estherville and Lamont are similar to the spectra of HEDs [12]. The subdued absorption features of Pinnaroo and Vaca Muerta are consistent with mixtures of metallic iron and pyroxene. The spectrum of Pinnaroo metal is relatively red-sloped, but does appear to have a slight spectral contribution due to pyroxene as seen by the shallow absorption centered near 0.9 µm. All the spectra appear to have been affected by some terrestrial weathering as seen by the weak absorption features in the spectra shortwards of 0.6 µm.

Implications for Dawn: It may be possible to determine if Vesta could be the parent body of the mesosiderites using instruments on Dawn. If a metallic iron-rich region is present on the surface of Vesta, this area would be expected to have weaker pyroxene absorption features than other regions on the surface. The gamma-ray and neutron spectrometer can determine the abundances of major elements such as O, Si, Fe, Ti, Mg, Al, and Ca [11]. A metallic iron-rich region on Vesta should have enriched concentrations of Fe, but depleted concentrations of O, Si, Ti, Mg, Al, and Ca compared to other areas.

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