

SPECTRAL REFLECTANCE PROPERTIES OF MESOSIDERITES. E. A. Cloutis¹, D. M. Applin¹, C. Kiddell¹, K. Tait², I. Nicklin², V. DiCecco², and P.S. Hardersen³. ¹Dept. of Geography, University of Winnipeg, 515 Portage Ave., Winnipeg, MB, Canada R3B 2E9, e.cloutis@uwinnipeg.ca. ²Royal Ontario Museum, Toronto, ON, Canada M5S 2C6. ³Dept. of Space Studies, Stop 9008, University of North Dakota, Grand Forks, ND, USA 58202.

Introduction: Mesosiderites are a class of meteorites that consist of variable amounts of metal plus embedded silicates, including pyroxene, olivine, and plagioclase [1]. Their origin remains uncertain, with the leading hypotheses being that they are samples of differentiated bodies or impact melts [2, 3]. To date, no strong contenders for their parent bodies have been identified. This stems, in part, from the lack of knowledge of mesosiderite spectral reflectance properties. To better enable identification of mesosiderite parent bodies, we undertook a spectral reflectance study of a number of mesosiderite slabs and saw-cut powders.

A number of asteroids have been identified whose reflectance spectra are consistent with metal plus variable amounts of pyroxene [4]. A tentative link between mesosiderites and asteroid Psyche is suggested by the fact that some telescopic spectra of Psyche indicate the presence of small amounts of pyroxene [4,5,6], whose abundance may vary across the surface [7,8]. Psyche is also of interest because a mission to it has been selected as a NASA Discovery class mission [9].

Methodology: A total of 5 different mesosiderites were included in this spectral survey and the results for 3 are reported here (Table 1). The samples included rough, unpolished saw-cut faces and saw-cut fines that were saved during dry cutting with a diamond wire saw. For the slabs, we tried to ensure that any striations induced during saw cutting were oriented perpendicular to the principal plane of the spectral measurements.

Reflectance spectra were acquired from 0.35-2.5 μm using an ASD FieldSpec 4 instrument and measured relative to a calibrated Spectralon disk. Spectra were acquired at $i=30^\circ$ and $e=0^\circ$; a total of 1000 spectra were collected and averaged to improve the SNR. Quick-scan (<1 hour/sample) XRD data were acquired of powders of the samples to identify the major phases using the ROM's Bruker D8 XRD instrument.

Because mesosiderites are normally heterogeneous in visible metal:silicate at the mm-cm scale, multiple spots (~5 mm in diameter) were acquired for the larger slabs. Duplicates of powder spectra were measured after emptying and refilling the sample cup.

Results: Saw-cut mesosiderite slabs normally show areas of bright metal and very dark silicate inclusions, particularly when the silicate inclusions are fine-grained. This results in generally lower overall reflectance than would be the case of pure silicates. Darkening is likely due to dispersal of fine-grained opaques from the impact event.

XRD analysis indicated the clear presence of metal and enstatite in the samples, with less certain identifications of sulfides, olivine, chromite, cristobalite, and anorthite in some of the samples. These identifications will be firmed up in the future. Raman analysis has verified the presence of olivine.

NWA 2932: This mesosiderite was available as multiple slabs with rough saw-cut faces and as a fine-grained saw-cut powder. It has only been cursorily described, containing olivine (Fa_{29.4}) and pyroxene (Fs_{31.3}) [10]. The reflectance spectra of different spots on the slabs (Fig. 1) show variable overall spectral slopes from blue to slightly red, and visible region reflectance of ~6-15%. These differences are due to factors such as surface roughness and variable metal:silicate ratios in the analyzed spots. In all cases, absorption bands attributable to orthopyroxene, centered near 0.92 and ~1.9 μm , are evident. The position of the 2 μm region band is difficult to assess because it is broad and weaker than the 1 μm region band and some of the spectra also show evidence for incipient alteration in the form of a narrow ~1.9 μm absorption band. The spectra are consistent with orthopyroxene, but with lower reflectance and band depths relative to pure pyroxene [11]. The broadness of the 1 μm region pyroxene absorption band suggests that it may be optically saturated, which would be expected for large (>~250 μm pyroxene grains).

In contrast to the slab spectra, the saw-cut powder, which appears to have a significant fine-grained (<5 μm) component, shows a weak 1 μm region pyroxene absorption band and a poorly expressed 2 μm region band - suggested by the broad concave-up shape of the spectrum in this region. The lack of strong mafic silicate absorption bands is consistent with saw-cut powder spectra of pallasites, where an expected olivine absorption band is weak/absent, likely due to the fact that very fine-grained mafic silicate spectra are dominated by surface rather than volume scattering [12].

Table 1. Samples included in this study.

Sample number	Sample type
NWA 2932	1 slab, powder
NWA 7132	1 slab
NWA 10765	2 slabs

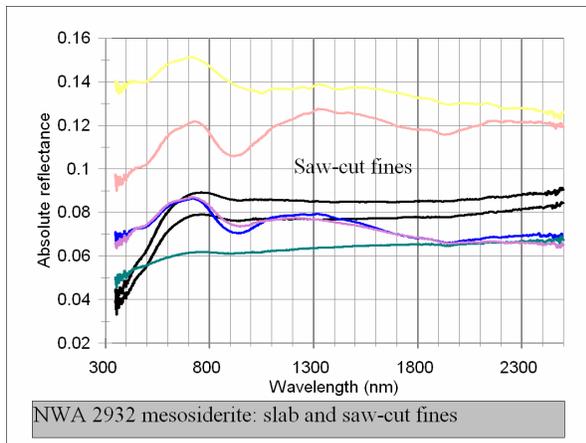


Fig. 1. Reflectance spectra of NWA 2932. Two black spectra are of the saw-cut fines.

NWA 7132: NWA 7132 was described as having metal clumps (35 vol.%), noritic diogenite (orthopyroxene (~Fs₃₂) and plagioclase) clasts (60 vol.%), and large (to 5 mm) olivine (Fa_{13.3}) xenoliths mantled by eucritic melt crystallization (5 vol.%) [13]. The two acquired spot spectra (Fig. 2) show weak pyroxene absorption bands near 0.9 and 1.9 μm , consistent with the presence of pyroxene. The red slope of one of the spectra indicates a strong metal contribution.

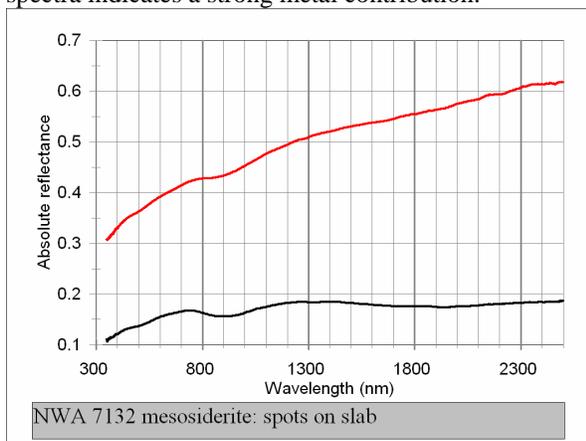


Fig 2. Reflectance spectra of NWA 7132.

NWA 10765: NWA 10765 has been described as consisting of aggregates of predominantly orthopyroxene (Fs_{~27}Wo_{~2.1}) plus ~30 vol.% metal and ~5 vol.% anorthite, and a number of accessory phases [14]. In sharp contrast to the other mesosiderite spectra, its spectra are dominated by strong pyroxene absorption bands (Fig. 3). The overall blue slope of the spectra is attributable to the fact that spots on slabs rather than powders were measured. The dominance of the orthopyroxene is such that even minor Fe²⁺-related absorption bands are seen in the 0.5-0.6 μm region [15].

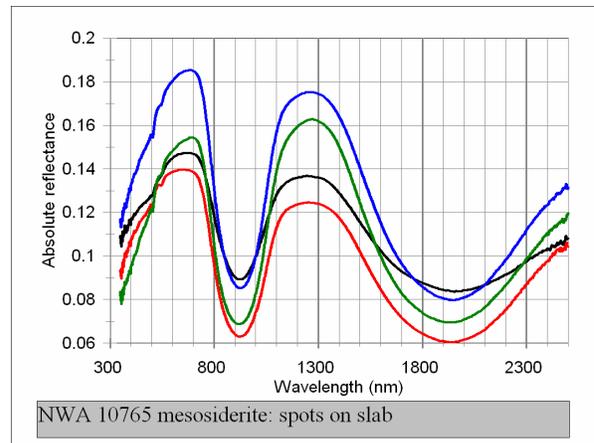


Fig. 3. Reflectance spectra of NWA 10765 slab spots.

Discussion: Reflectance spectra of these mesosiderites demonstrate that, on the whole, slab spectra exhibit pyroxene-attributable absorption bands. In the case of the powder spectra, the absorption bands are subdued, likely due to the fine-grained nature of the pyroxene in saw-cut powders. It is likely that a mesosiderite parent body will exhibit spectral behavior intermediate between these end members, but with pyroxene absorption band(s) being readily detectable.

The reason why the NWA 10765 spectra are so strongly dominated by pyroxene is not fully known, although it does have larger and lighter-colored silicate inclusions than the other mesosiderites. The shock stages for these samples are S2 (NWA 2932), "moderate" (NWA 7132), and "low" (NWA 10765). Weathering stages are W2 (NWA 2932) and "low" (NWA 7132, 10765). It is likely that a combination of factors contribute to the spectral differences.

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