REFLECTANCE SPECTRA OF RARE METEORITE GROUPS.
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Introduction: Reflectance spectra of meteorites are the best spectral analogs for asteroids. However, many of the "rarer" meteorite groups are not well represented in our spectral databases. To remedy this situation, we are obtaining meteorite reflectance spectra of a number of rarer meteorite spectra as part of a project to use machine learning to mineralogically classify asteroids using meteorite spectra as a training set [1-3]. If asteroids can be linked to particular meteorite groups, the cosmochemical meaning of the taxonomic distribution of asteroid classes in the main belt [4] can be better understood. Models for the scattering of planetesimals [5] into the main belt can be tested.

For machine learning to "learn" to predict meteorite classes, multiple meteorite spectra of every meteorite class are necessary to train models. To increase the number of meteorite spectra available for our machine-learning project, we have acquired over 100 Antarctic meteorite chips from the Meteorite Working Group (MWG). We here discuss spectral properties of some of the "rarer" meteorites in our sample with the least amount of terrestrial alteration. To date, we have obtained 46 meteorite spectra (**Table 1**) of what we consider "rarer" meteorites; additional spectra are forthcoming as time and funding allow.

Table 1. List of the number of meteorite spectra that we have obtained of these "rarer" meteorite groups.

Meteorite Group	Number
Aubrite	1
C4/5	1
CB	1
CH	1
CK	7
CM	3
CO	3
CR	1
CV	5
E3-an	1
EH	7
EL	6
Mesosiderite	2
R	4
Ureilite	2
Winonaite	1

Data: Chips of a few hundred milligrams were requested. All the meteorite chips were lightly crushed by hand and then sieved to particle sizes less than 125 µm and sent to the Keck/NASA Reflectance Experiment Laboratory (RELAB) at Brown University. Reflectance spectra were measured from 0.32 to 2.55 µm at a sampling interval of 0.01 µm. The incidence angle was 30° and the emission angle was 0°.

The weathering grades for these "rarer" meteorites ranged from A/B to C. Each spectrum was visibly checked for the effects of terrestrial weathering. Often, the weathering grade did not correlate with the amount of visible terrestrial weathering apparent in the spectrum.

Discussion: A relatively large number of the enstatite-rich meteorites have reflectance spectra that appear mostly unweathered (**Figure 1**). All of the spectra appear relatively "flat" and "featureless" due to their virtually FeO-free silicates. Some spin-forbidden bands in the visible are present in some of the spectra. As expected, the aubrite has the highest albedo.

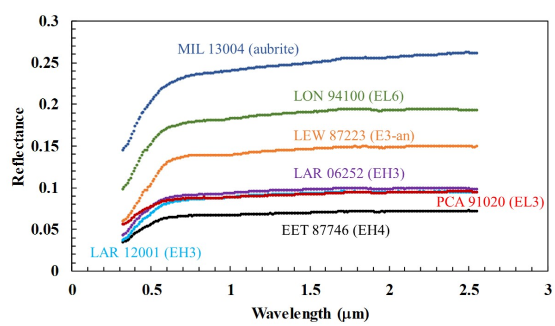

Figure 1. Visible and near-infrared reflectance spectra of the enstatite-rich meteorites.

A relatively large number of carbonaceous chondrites of petrologic types 3 to 6 also appear relatively unweathered (**Figure 2**). All of the meteorites have absorption features of varying strength due to olivine. A few of the meteorites have weak pyroxene features centered at ~1.9-2.0 µm.

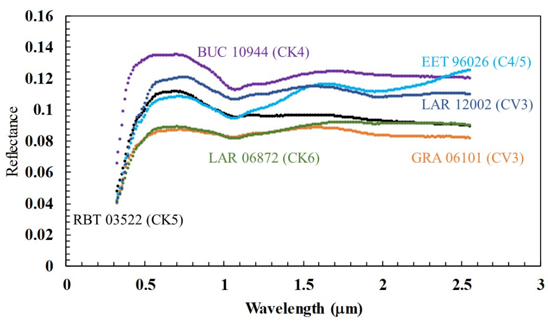

Figure 2. Visible and near-infrared reflectance spectra of the carbonaceous chondrites of petrologic types 3 through 6.

Two of the CM chondrites appear relatively unweathered (**Figure 3**). Both meteorites have relatively low albedos. LAP 031166 has a weak absorption feature centered at ~0.7 µm while MIL 13005 has a number of absorption bands from ~0.7 to ~1.8 µm. The spectra of both meteorites are consistent with their classifications [6]. LAP 031166 is classified as a CM2.1 [7] while MIL 13005 is a CM1-2, a CM chondrite that is a breccia containing materials of petrologic type 1 and type 2.

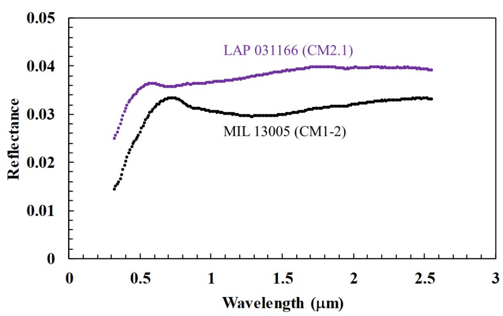

Figure 3. Visible and near-infrared reflectance spectra of the CM chondrites.

Table 2 lists the meteorites, their classification, and their asteroid taxonomic class determined from their spectra. The taxonomic classes are from the Bus-DeMeo taxonomy [8]. The enstatite-rich meteorites tend to fall within the Xc or Xe class. The carbonaceous chondrites of petrologic grades 3 to 6 tend to fall within the K class. LAP 031166 (CM2.1) falls within the Ch class while MIL 13005 (CM1-2) falls within the K class. The K class of asteroids appears to contain a wide variety of carbonaceous chondritic material.

Table 2. The meteorites, their classifications, and their asteroid taxonomic classes.

Meteorite	Class	Asteroid Class
BUC 10944	CK4	K
EET 87746	EH4	Xc
EET 96026	C4/5	K
GRA 06101	CV3	K
LAP 031166	CM2.1	Ch
LAR 06252	EH3	Indeterminate
LAR 06872	CK6	K
LAR 12001	EH3	Xe
LAR 12002	CV3	K
LEW 87223	E3-an	Xe
LON 94100	EL6	Xc
MIL 13004	Aubrite	Xc
MIL 13005	CM1-2	K
PCA 91020	EL3	Xc
RBT 03522	CK5	K

Conclusions: We are in the process of acquiring more meteorite spectra for a machine-learning project to mineralogically classify asteroids. The spectra presented here show the range of spectral properties of enstatite-rich meteorites, carbonaceous chondrites of petrologic types 3 to 6, and CM chondrites.

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