Near-IR Reflectance Properties of Type 3 Ordinary Chondrites.

A. Sissay[1, 3], D. Ostrowski[3], K. M. Gietzen[3], & D.W.G. Sears[2,3]. [1]Southern Univ. and A&M College, Baton Rouge, LA 70813. [2]Dept. of Chemistry & Biochemistry, Univ. of Arkansas, Fayetteville, AR 72701. [3]Arkansas Center for Space & Planetary Sciences, Univ. of Arkansas, Fayetteville, AR 72701.

Introduction: Type 3 ordinary chondrites are the most primitive members of the largest meteorite class. "Most primitive" mean least altered since formation. The largest meteorite class is the ordinary chondrites, which are subdivided into H, L, and LL on the basis of iron and amount of oxidation (i.e. amount of FeO in silicates relative to Fe metal). Type 3 are sometimes called the "unequilibrated" ordinary chondrites while type 4-6 are sometimes called "equilibrated".

Meteorites come from asteroids, but we don't know which ones. The only way to study asteroids is by reflected sunlight, and the best way to get chemical information is by IR spectroscopy.

From our point of view, there are three important minerals: olivine ($(Fe,Mg)_2SiO_4$), pyroxene ($(Fe,Mg)SiO_3$), and the pyroxene in two crystal forms, orthorhombic and monoclinic. These are referred to as orthopyroxene (OPX) and clinopyroxene (CPX). The type 3 ordinary chondrites are subdivided into type 3.0 to 3.9 reflecting the amount of metamorphism on their parent asteroid. (Metamorphism is heating without melting).

Experimental: IR Data from RELAB database which is funded by NASA was downloaded for type 3 ordinary chondrites in order to graph the data and then determine the percent of CPX and OPX. Also, courtesy of NASA, eight additional samples were obtained from Johnson Space Center. After graphing by simply using the eye and ruler the percentage was determined by comparing this result to already graphed data by other scientists [1]. The already published work by the scientists has reflectance spectra of enstatite (OPX and CPX) end members and their seven mass fraction mixtures with different particle sizes [2].

After obtaining percent CPX by using an easy technique, a more sophisticated and accurate method was utilized to obtain percent CPX. The Modified Gaussian Model (MGM) [3] software that has the capabilities of intensely analyzing an IR data gives a band strength that will lead to the calculation of percentage.

Results: The results for the type 3 (3.0-3.9) ordinary chondrites is shown in the Table 1. The band dip for 1µm region ranged from 0.88 to 0.94 µm. While for the 2 µm region varied from 1.87 to 2.05 µm.

Table 1: CPX percentages for type 3 chondrites determined by visual inspection of the spectra.

Name	Class	N	1 µm	% CPX	2 µm	% CPX
Dimmit	H3.7	1	0.94	44	1.93	55
Acfer 111	H3	1	0.92	28	1.90	43
Y-74191	L3.7	5	0.90	14	1.90	43
ALHA77214	L3.4	2	0.92	28	1.94	58
Mezo-Madaras	L3.7	4	0.92	28	2.00	71
Hedjaz	L3.7	2	0.93	36	1.97	67
Krymka	LL3.1	2	0.94	44	1.95	62
Hallingeberg	L3.4	1	0.94	44	2.01	70
Moorabie	L3.8	1	0.91	21	2.00	70
Bishunpur	LL3.1	1	0.93	36	bd	Bd
Dhajala	H3.8	1	0.90	14	1.92	52
Hedjaz	L3.7	1	0.91	21	1.89	36
Suwahib (Buwah)	H3.8	1	0.92	28	1.92	52
Khohar	L3.6	1	0.92	28	1.96	64
GRO95505	3.40	1	0.93	36	1.94	58
GRO95504	3.50	1	0.91	21	1.87	24
ALHA77216	3.7-3.9	1	0.88	bd	1.90	43
GRO06054	3.60	1	0.94	44	1.98	69

N, number of replicate samples.
bd, below detection.
The replicate measurements suggest that 1 σ uncertainties on CPX are ~35% for the 1µm band and ~15% for the 2 µm band.

Discussion: In order to easily interpret the percentage, the data by Sunshine et at. (1993) was graphed in a different way. The Sunshine graph was split into two regions 1 µm and 2µm wavelength regions. This way two graphs were plotted, percentage against 1 μm and 2 μm wavelength regions.

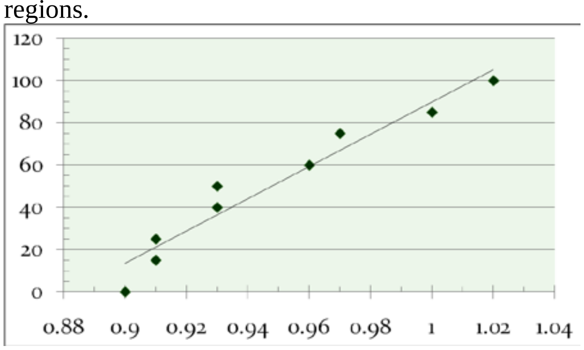

Figure 1: Graph for the 1μm region with calibration curve drawn across the graph.

In theory, as one goes from type 3.0 to 3.9 ordinary chondrites, the amount of CPX should decrease relative to the OPX content. Likewise, for the results obtained from the research, the same rules should apply. But the expected trend was not seen in our results. The data in Table 1 was graphed so that it can easily be interpreted as shown below in Figures 2 and 3.

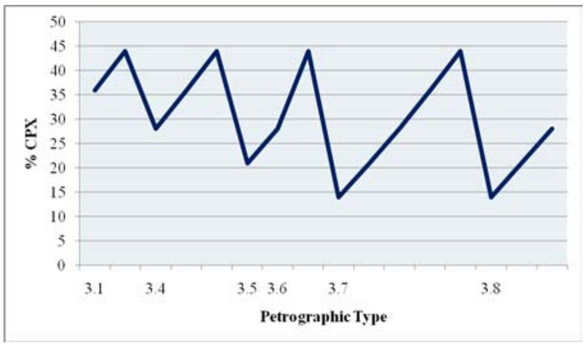

Figure 2: Graphed data from Table 1 for the 1 μm region.

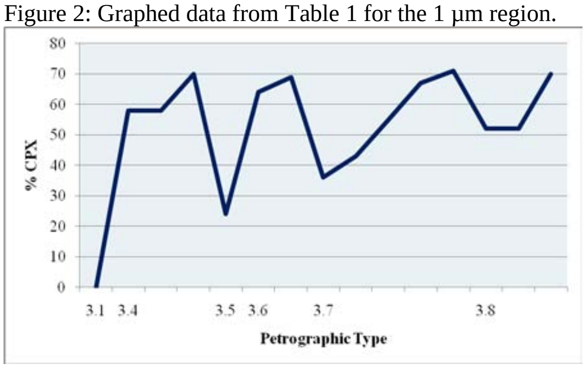

Figure 3: Graphed data from Table 1 for the 2 μm region.

The percentage results shown in Table 1 are not as accurate for two main reasons. The technique used in determining the percent CPX for each sample was by using a ruler and eye balling the band dips around the 1μm and 2 μm regions. For example, for the four Y-74191 chondrites studied, the percentage results are different. In contrast to the result in Table 1 for these type 3.6 chondrites, the CPX percentages should have been the same. The other problem in the results obtained was the difference in the CPX percentages for the 1 μm and 2 μm wavelength regions. The percentages for these two regions should have been more or less the same.

In order to address these problems, a more intricate technique was used, the Modified Gaussian Model (MGM) software. After obtaining the band strength from the software, the following equation was used in order to determine percentages.

$$CBSR = \frac{\text{Band Strength of the OPX component}}{\text{Band Strength of the CPX component}} .....(1)$$

In equation 1, CBSR stands for Component Band Strength Ratio for the CPX and OPX components [4]. The direct results of the software were significant, different from previously recorded data for the same samples studied in this research. For example, for one of the chondrites, Mezo–Madaras, the percentage result from Table 1 was compared with the MGM amount of CPX/OPX.

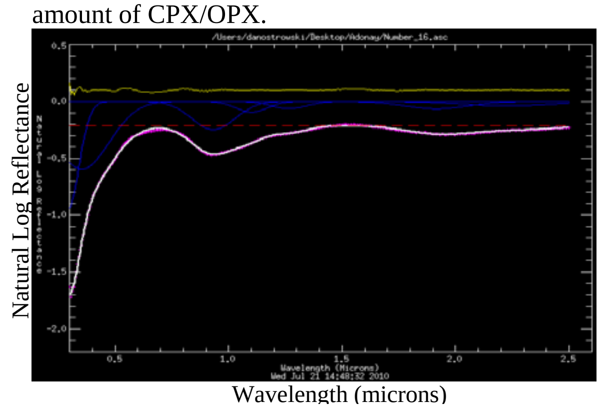

Figure 4: Fitted MGM graph of Mezo-Madaras.

From Figure 4 the band strength was easily obtained that led us to the percent CPX of 34.5% for 1 μm and 52% for 2μm regions by using equation 1. This percentage is different from previously extracted data of 28% for the 1 μm region and 71% for the 2 μm by just eye balling the graph. This inconsistency was common for most of the samples

Conclusion: It is possible to determine the amount of CPX/OPX in a particular sample by just looking at near IR graphs but to some certain degree of accuracy. To get a more reliable or accurate result a more sophisticated procedure has to be utilized, like the MGM software.

References: [1] Sunshine, J., et at. *Journal of Geophysical Research* 98, no. E5 (1993): 9075-9087. [2] Ibid., pp. 9076. [3] Sunshine, J., et at. *Journal of Geophysical Research* 95, no. B5 (1993): 6960-6965. [4] Sunshine, J., et at. *Journal of Geophysical Research* 98, no. E5 (1993): 9080.