Implications for the Band I Visible Peak (0.6-1.0 µm) Feature Shift of Ordinary Chondrites

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Motivation

Extensive databases of meteorite and asteroid surveys exist, however correlating the two data sets has yet to be completed. There are three asteroid data sets of particular interest: SMASS I, SMASS II, and S/OSs. These surveys contain approximately 2500 asteroid spectra up to 1 micron (µm). The most prevalent meteorite falls, the Ordinary Chondrites, still do not have well defined parent bodies. In order to obtain more information from the asteroid surveys in the hope of discerning potential Ordinary Chondrite parent bodies, our intent for this study is to generate a novel characterization method using the visible peak feature between 0.6-1.0 microns for identification of the types of Ordinary Chondrite (H-, L-, LL-) being viewed.

Introduction

Roughly 75% of meteorite falls/finds are Ordinary Chondrites, yet we know little about them with regard to potential parent bodies in the main asteroid belt [3]. With the use of remote observation in the visible to near infrared (0.4-2.5 µm), we are able to identify asteroids with similar mineral assemblages to that of Ordinary Chondrites [4,5]. The process is time consuming and often effects of the atmosphere can render the process unresolved. There have been several spectral surveys which sample to1 microns (SMASS I, SMASS II, and S/OSs) [6-8] which cut off the Band I and Band II features which are typically used for characterization. We began our survey of Ordinary Chondrites from the RELAB [9] and Gaffey [10] data sets to see if a correlation can be exploited between the peak feature (0.6-1.0 µm) and composition. This peak feature shares a limb with the Band I feature [11-15], so there is potential for a systematic shift between both features.

Methods

For this study, we downloaded the pre-existing data sets [9,10]. Since this study focuses on Ordinary Chondrites, all other meteorites in the databases were unessential, thus not considered for this data set. For each ordinary chondrite sample, we generated a plot correlating reflectance to wavelength. Then a polynomial fit was performed to determine the peak feature’s position between 0.6-1.0 µm. Accumulation of these peak positions, reflectance at the peak positions, sample types, and file source data were compiled into comparison cluster charts to discern potential relationships among the resulting 230 samples.

Figure 1 The cut surface an LL5 chondrite, Krynka, with the fusion crust shown (A) [1], an exposed chondrule with two attached chondrules (B) [2], and a chondrule in a polarized thin section (C) [2].

Study Population of Ordinary Chondrite Classes

<table>
<thead>
<tr>
<th>Meteorite Fall v Find Inventory by 1997</th>
<th>Ordinary</th>
<th>Fall Type</th>
<th>Find Type</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class</td>
<td>Falls</td>
<td>Falls</td>
<td>Finds</td>
<td>Falls + Finds</td>
<td>%</td>
</tr>
<tr>
<td>Ordinary</td>
<td>718</td>
<td>1038</td>
<td>2541</td>
<td>3581</td>
<td>86.0%</td>
</tr>
<tr>
<td>Chondrites</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>305</td>
<td>460</td>
<td>1165</td>
<td>1661</td>
<td>50.4%</td>
</tr>
<tr>
<td>L</td>
<td>340</td>
<td>641</td>
<td>981</td>
<td>1392</td>
<td>42.4%</td>
</tr>
<tr>
<td>LL</td>
<td>73</td>
<td>160</td>
<td>166</td>
<td>239</td>
<td>6.2%</td>
</tr>
</tbody>
</table>

Figure 2 Reflectance spectra for ordinary chondrite Bensor [9]. an LL6, illustrates the spectral features needed for 'best' characterization of asteroids.

Figure 3 Reflectance spectra for asteroid 1007 Pavlovia [9], illustrates the missing characterization features when utilizing SMASS I, SMASS II and S/OSs data sets for characterization and parent body identification.

Results

Preliminary results show that cluster patterns overlap significantly between the Ordinary Chondrite types. Discerning variances becomes difficult when looking at the whole Ordinary Chondrite population. Separating the main types (H-, L-, LL-) while noting their metamorphic grades doesn’t provide much in the way of further elaboration. The information that presents itself, while albeit chaotic, does show cluster patterns for the main types. When comparing the metamorphism to peak position for the OCs with regard to standard deviation, a pattern presents itself. With increasing metamorphism in all types, the peak position appears to shorten. This is expected from heating of original mafic materials and formation of lower temperature ground mass feltspar.

Figure 4 Population characteristics of the 1997 meteorite catalogue set illustrates expected population ratios (A) [16], the population characteristics of the study group (B), and the distribution of the study population peak wavelength positions (C). This illustrate that the data sets used for this study are divergent to the population ratios in the catalogue and the spatial distribution is grouped with considerable overlap in the visible peak spectra between the main types.

Conclusions

These preliminary results suggest that while currently not robust characterization method, the peak position of the visible (0.6-1.0 µm) wavelength does vary for the main types (H-, L-, LL-) of Ordinary Chondrites. L-Chondrites have the widest breadth of coverage, potentially due to a cataclysmic break up of the parent body and the potential of two parent bodies [17]. H-Chondrites fall within the tightest cluster region, however are under represented within the population. LL-Chondrites are also fairly tightly clustered, however not as much as the H-Chondrites. There is considerable overlap between the main types, however the data suggests that the peak position shift may be used as an elimination metric. Initial results presented here utilized slabs, thin sections, chips, ground samples and specific site samples to aid in overall clarity. Since our purpose is to provide a method of characterization for potential parent bodies of Ordinary Chondrites in the main asteroid belt, only particularites are to be selected for use to represent surface effects of space weathering on asteroids. More in-depth statistical analysis to determine statistical relevance of differences between the main types (H-, L-, LL-) will be applied to provide more quantitative determination of peak clustering. Work on this project is still progressing.

Bibliography


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