Early Analysis of Fe/Si Meteorites In Order to Determine a Connection with Asteroids

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Introduction. Spectral reflectance curves have been taken of many asteroids as well as many meteorites and are necessary in order to understand the origin of the solar system. Meteorites are known to come from asteroids and outlying planetary bodies including Mars. A problem arises upon comparison between the meteorites and the asteroids in which they are believed to originate from. The differences are believed to be caused by a phenomenon known as space weathering. The weathering processes that occur on an asteroid's surface are not fully understood but fluidization of the regolith seems to be a likely explanation.

This work is part of a larger explanation as to why meteorites and asteroids seemingly have no common traits. *Gaffey* [1976] discussed the relevance of the comparison of several meteorite, rock, and mineral spectra with that of asteroids. It is essential to have a set of standard spectra for the mineralogy and petrology of asteroid surfaces so that the processes that occur may be better understood. *Taylor et al* [2001] point out that the three principle optical manifestations of space weathering, albeit on lunar materials but still applicable, are: (1) overall reduction of reflectance; (2) general attenuation of diagnostic absorption bands; and (3) development of a red-sloped continuum. These effects have been noted to increase with surface exposure and, as *Taylor et al* [2001] goes on to say that it is the accumulation of nanophase Fe that dominates his samples and probably causes the shifts.

We suggest that future data will require the conclusions drawn here as a standard in which to compare. Fluidization is a factual occurrence that is a proposed mechanism for space weathering on asteroidal bodies and, it is suggested, that it may be the main reason as to why meteorites look nothing like their genetic parents

Experimental setup. The Andromeda environmental chamber was used as a test bed. The chamber can simulate the environment through pressure and light. While the chamber does not offer a full space-vacuum, it is adequate. Sand and Iron grains ranging in size exemplary of that found on an asteroidal body regolith were used. The composition was varied ranging from 5% Fe up to 50% Fe in 5% increments. Other than the changing composition, the only other factor present was the amount of water absorbed by the samples. The water concentration might deviate significantly from that of asteroidal conditions. For the first trial, a cylindrical pan 40.64 cm in diameter and 3.81 cm in depth was used with the 5% Fe, 95% Sand mixture. A Xenon lamp with a solar filter was used in order to simulate the sun's effects on the sample. The chamber was then pumped down to 5 mbar. The pressure in the chamber was measured throughout the experiment
and the effects on the mixture were observed by video camera. The spectrum was taken before and during vacuum in order to determine any change that might occur due to processes such as fluidization. After the trial was run, the chamber was allowed to equilibrate with atmospheric pressure and then opened. The new sample was placed in the chamber and the spectral determination was repeated. This was done until a 50% Fe and a 50% sand mixture was achieved.

Results and Discussion. From the trials run, the following general observations could be made:

1. De-volatilization, where iron and sand separation was clearly marked, occurred only when the pressure was decreased too quickly and seemed to be influenced by the container.
2. There were no changes in the spectra before and during vacuum unless the chamber was pumped down too quickly causing a fluidization-like process.
3. Previous determinations have showed that the soil could contain up to 11% absorbed water [3].

The important thing to look for is the lack of equal spacing between the peaks, especially the separation between the 5% and 10% with the 15% and 20%.

The unequal separation is thought to be caused by the small amount of iron in the sample. Essentially at 5% and 10% it is thought that the iron has no great influence on the sample and therefore it is primarily a spectrum of the sand. It is not until the 15% that there is a good influence from the iron. This could also be due to a lack in equal mixing but the trials were repeated and the same results were obtained.

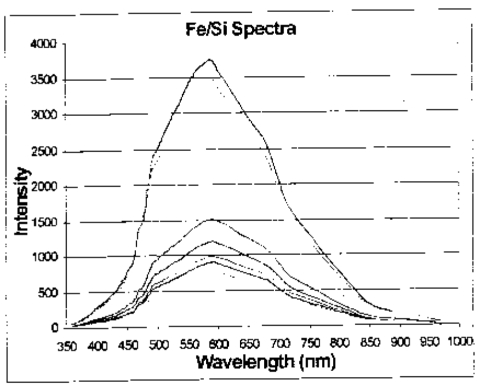

Fig. 1. Observed spectra beginning with the 5% Fe at the top and moving down through 50% Fe. The light source spectrum has been removed. Note the separation.

The graph shows that as the iron increases, the intensity decreases, as is expected. The Albedo was then calculated and graphed and illustrates that as the iron concentration increases, the ratio of the reflected light to incident light decreases. This aligns itself with the initial spectra and is what is expected. The incident light is constant, so only the reflected light changes. This was made in order to determine if a red-shift was made.

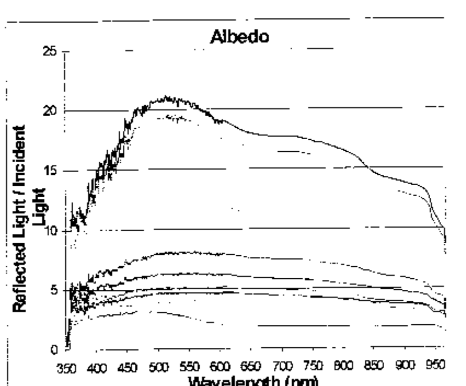

Fig. 2, the lines measure the albedo at the various iron concentrations where the top line illustrates 5% and the bottom line measures 50%.

The data obtained is relevant to the analysis of asteroids and meteorites in that it tries to begin the formation of the link between the two. The data illustrates everything that is expected before a weathering effect has occurred. This data along with other research will help to explain the difference in spectra between meteorites and their parent bodies, the asteroids.

Conclusions. The basis for this research was to create a standard for comparison from which future experiments could be compared. The data provided here along with data from past and future experiments will provide a clearer picture on what is happening on asteroids as they make their transit from space to the meteorites that we find here on earth. The problems that come about in this type of simulation arise because of the actual apparatuses that are used. It is apparent that fluidization occurs, but it almost always occurs near the walls of the container. It must be influenced not only by the container, but also by the rate at which the vacuum is drawn.

The data obtained creates a standard for future simulations which will be looking at fluidization in a setting that more closely simulates the environment on an asteroid. Fluidization simulations have already been performed and, along with this data, begin to provide a better insight on what is actually occurring that causes meteorites and asteroids to differ.

The 5% and 10% readings seemed to group too close with a large separation from the 15% and 20% but this can be explained by the thought that with such a low concentration of iron, the experimental setup was only able to analyze what was a majority of sand, causing the readings to cluster. The trials were repeated and the same results were obtained which would tend to cancel out poor mixing. The data confirms the idea that some sort of space weathering is needed on order to cause a large difference in spectra.

References: [1] Gaffey (1976) *Journal of Geophysical Research, 81-5, 905-920.* [2] Lawrence A. Taylor *et al.* (2001) *Meteoritics & Planetary Science, 36, 285-29.* [3] M.S. Kareev *et al.* (2002) *Lunar and Planetary Science XXXIII.* [4] D. Glen Akridge and Derek W.G. Sears. (1999) *Journal of Geophysical Research, 105-E5, 11853-11864.* [5] Gaffey *et al.* (1993) *Meteoritics 28, 161-187.* [6] B.E. Clark *et al.* (2001) *Meteoritics and Planetary Science 36, 1617-1637.* [7] Clark R. Chapman. (1996) *Meteoritics and Panetary Science 31, 699-725.* [8] Carle M. Pieters *et al.* (2000) *Meteoritics and Planetary Science 35, 1101-1107.*