

Abstract:

As a Planetary Data System College Student Investigator, I analyze images from the Deep Impact mission. In this proposal, we present results from our analysis of radial profiles of cometary ejecta from the Deep Impact mission. The primary goal of the Deep Impact mission was to collect information about structure and composition of the nucleus of comet 9P/Tempel 1 to explain the evolution and development of comets. The time sequence of images obtained by the Medium Resolution Instrument after the impact allows us to determine variations in the properties of the cometary ejecta that reflect differences in the cometary nucleus. Specifically, we study variations in the brightness and the optical depth of the ejecta. To analyze these images and obtain the optical depth, we compared the brightness of the cometary edge before and after impact. This allowed us to understand how much the ejecta was blocking the edge. After analyzing the images, we have found that the ejecta have non-monotonic variations in optical depth. This suggests stratification of different materials inside the nucleus of comet 9P/Tempel 1, assuming that the ejecta originated from sequentially lower layers in the cometary nucleus. More detailed compositional variations inside the nucleus can be determined through the simultaneous analysis of the brightness and optical depth of the ejecta. With a better understanding of the cometary layering, we can shed light on cometary evolution. The layering may help discover where sublimation of volatiles and displacement of other materials occur, when the comet makes periodic revolutions around the Sun. This work is funded by NASA's Planetary Data System (PDS) College Student Investigator (CSI) program.

Introduction:

On July 4, 2005, Deep Impact spacecraft collided with a section of comet Tempel 1. This was no ordinary collision, but a scientific experiment. This single collision provided information to scientists regarding the comet Tempel 1 and the solar system. The four main goals of the mission were to gain information about the nucleus of the comet, to obtain data regarding properties of the surface layers such as “density, porosity, strength and composition,” to assess the relationship between the cometary nucleus and surface layers, and finally to understand the development of the cometary nucleus (A’Hearn et al., 2007). With these data, scientists can then apply these principles to other comets’ formations and even further to the formation of the Solar System.

After the mission, scientists working on the Deep Impact project, as well as other scientists from around the world, began to analyze the recorded images from the impact. The initial results showed that the ejecta cloud moved outward at a rate of 3 km/s which suggests a majority of “gas-driven” particles (A’Hearn et al., 2005). Tools like spectroscopy were used to determine the composition of the nucleus. The dust size was determined to be predominantly between 0.5 to 1 μ m (Meech et al., 2005). The composition of these particles was also determined, and the most “dramatic” proportional increase of materials ejected from the impact was the abundance of organic materials which included CO₂ and HCN (hydrogen cyanide) that may include in CH₃CN (methyl cyanide) (A’Hearn et al., 2005). There were also observations that suggested water ice. This was evidenced by the “bluening” of images observed on earth in the visible and

near-infrared (IR) ranges (Knight et al., 2007). The bluening was also in part caused by the increase in smaller grain size in the ejecta (Knight et al., 2007).

Much of the data that has been recovered has been analyzed using a technique called spectroscopy to determine composition. The information using the optical and near-IR wavelengths have provided many useful properties of the comet, such as the ejecta speed, the strength and density of the material in the nucleus. However, there is still a lot more to be learned from observing the optical images from the Deep Impact mission. This includes the cross section of the ejecta that would determine the size of the particles which came from the top layers of the nucleus, the reflectivity, and the absorption from each particle. These properties can be determined by using the data collected by the Deep Impact mission and studying the optical depth at the edge of the comet before and after the impact.

Research Question:

By examining the properties of the Tempel 1 ejecta can we determine where distinct layers of the cometary nucleus originate?

Method:

To address this question, the images right before and after impact collected by the Deep Impact spacecraft will be utilized. All the research will be done on a Linux system, using Interactive Data Language (IDL). The images will be obtained from the Planetary Data System's Small Bodies Node website. They are the medium and high resolution images that have been reduced from the Deep Impact mission. The medium resolution images will be examined first because they were in focus during the first few seconds of

impact. The high resolution images will also be utilized but only after the medium resolution techniques have been perfected.

In studying the layers expressed in the ejecta, we will be analyzing the optical depth of the ejecta using the medium resolution images. The optical depth will be determined by comparing the intensity of the edge of the comet before the impact to that of the same position after the impact. Many points around the edge will be examined to increase statistical accuracy. The intensity curves will be analyzed over many images so as to see the changes over time. However, before the intensity curves can be analyzed, a parabolic fit of the dust intensity measured radially outward from the selected point must be subtracted out in order to accurately measure the change in intensity of the edge in question. Following this subtraction, the intensity after the impact at the edge of the comet (I) will be divided by the intensity before the impact at the edge of the comet (I_0). This should give a relation less than one and the optical depth (τ) is related to the natural log of this relation, $\tau = -\ln(I/I_0)$.

Thus far, the analyses have suggested there is layering present in the cometary nucleus. This is deduced because we have observed non-monotonic variations in the optical depth over time. Assuming that the ejecta came from sequentially lower levels in the nucleus, these variations are the result of different amounts of obstruction from the ejected particles. To solidify these conclusions, further investigations comparing the optical depth with the absolute brightness of the ejecta will need to be performed. These data will allow the measurement of the reflectivity of the ejected particles and thus relate the composition. This process will allow us to establish whether the composition of the nucleus contains water ices and where they lay.

It is important to study the layering in the comet to shed light on the evolutionary processes that the comet has undergone. The layering is most likely caused by sequential passes around the sun which cause sublimation of volatiles and displacement of other materials. Information from studies such as ours will help to resolve this process.

Timeline:

May 21: Rough Draft Due

July: Make Power Point presentation for Teleconference

July: Submit abstract for poster to DPS

July/August: Finish Analysis of Medium Resolution Images

October 7-12: DPS Meeting in Orlando, FL

April 2008: Finish Analysis of High Resolution Images

May: Submit Final Draft Paper

June: Present Final Paper to PDS Management Council

Works Cited

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Knight, Matthew, K. J. Walsh, M. F. A'Hearn, R. A. Swaters, B. A. Zauderer, N. H.

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