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Effects of low velocity impacts on basaltoids

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Abstract

We study the effects of low velocity impacts on basaltoids as analogue materials to HED meteorites and V-type asteroids. The aim of this study was to investigate changes to V-type asteroid spectrum under impacts and its implications to interpretation of remotly obtained spectra. We have performed number of low velocity ($\sim$ 4-7 km/s) impacts into various basaltoids and performed reflectance spectroscopy, of the samples before and after the impact.

Low velocity impacts enchance the spectroscopic features of the studied samples. In particular, the absorption bands are deepened and broadened. Overall the spectrum is brigther as compared to the spectrum of the solid samples before impact. The after impact spectrum resembles closly the spectrum of powdered samples.

The enchancement in the spectrum is mostly due granding of the sample during the impact. Effects of low velocity impacts can therefore be simulated by graining the samples. Future studies are needed to check for the possible effect of different grain sizes on spectrum.

1. Introduction

According to Antarctic Meteorite Collection (ANSMET program) less than 1% of collected meteorites belong to the so-called HED (howardite- eucrite-diogenite) meteorite group. Those meteorites have been identified to originate from asteroid (4) Vesta - the only currently known differentiated and intact asteroid in the Main Asteroid Belt. Few of the known HED meteorites cannot be chemically linked to Vesta, the most prominent ones include Ibitira and NWA011. Those meteorites among with other evidence suggest that additional differentiated bodies existed in the Solar System at some point during its history. The observational proofs for those bodies are however missing. This mismatch between in-situ meteoritic and observational asteroidal evidence is known as the "missing dunite" problem [1]. Several observational, dynamical, chemical and geological hypothesis were put forward to explain the mismatch. For example [1] suggested that the basaltic asteroids were "battered to bits" and are curently beyond our spectroscopic reach. More recently [2] showed that partial differentiation is possible, creating an alternative formation hypothesis for those bodies. Few of the hypothetical explanations of the missing dunite problem (such as modification of V-type spectra by space weathering or impact shocking) could be tested experimentally in laboratories. In this research we explore the possibility of using the Earth basalts and peridotites as analogues to HED meteorites. In particular we analyze the differences and similarities in chemical composition, mineralogy, reflectance spectra and matterial shock induced changes in the selected Earth basalts. The conclusion of this experiments may be applicable to HED meteorites and the topic of altering the surfaces of basaltoid-like planetary bodies.

2. Impact experiment

The basaltoids were shocked by impacting them with 1 mm stainless steel (470) projectile at a set speed between 4 and 7 km/s (Table 1) using the two stage light gas gun facilities based at the University of Kent, a detailed discussion of the methods and design can be found in [3]. The peak pressures were calculated using the Planar Impact Approximation [5]. This assumes a linear wave speed equation for both the basalt target and stainless steel projectile and that the projectile hit a solid basalt (i.e. no allowance of made for the porosity of the target). This latter assumption is considered reasonable as only a peak pressure is being found, not the full pressure history of an impact vs. time. The required C and S values used for the calculations are 3800 $\frac{m}{s}$ and 1.58 for the steel projectile [4] and 4960 $\frac{m}{s}$ and 0.88 for the basalt [4].

Sample	Shot speed ($\frac{km}{s}$)	Peak Pressure Approximation (GPa)	Crater diameter (mm)
J3-2	6.42	105.4	22.2 ± 1.0
KG1-3	6.35	108.9	23 ± 1.5
MW3-2	4.00	59.5	20.2 ± 0.9
MN5-8	3.77	56.1	13.6 ± 0.1

Table 1: Impact parameters.

The powdered ejecta was removed from the sample after performing the experiment.

3. Spectroscopy

For each sample we obtained 4 spectra, one before the impact experiment and three after. The spectra before the experiment were taken from powdered samples, whereas the spectra after the experiment from solid samples containing impact craters. In black we denote the spectra from the powdered samples, in red spectra from the craters centers, in green spectra from the craters walls and in blue spectra outside the impact craters. In Fig. 1 we present our preliminary normalized and slope removed spectra for the sample J3-2.

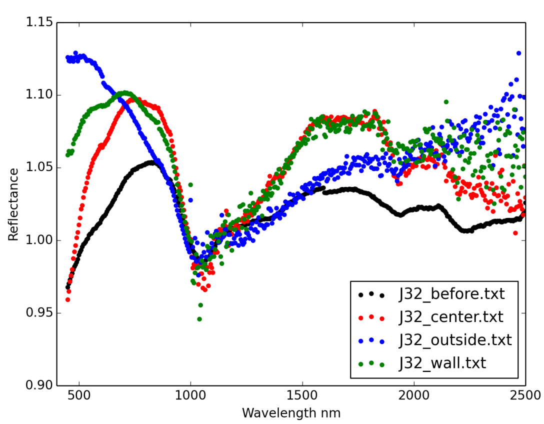

Figure 1: Slope-removed J3-2 spectra. All spectra shifted to 1.0 at 1000 nm for comparison.

4. Summary and Conclusions

For samples alkali basalt J3-2, basanite MW3-2, nephelinite KG1-3 rock lithology was modified to lighter at crater centers (most likely due to mechanical damage). For peridotite-harzburgite (MN5-8) there is no visible change in the color of lithology at the crater center. The color of lithology is an important factor influencing reflectance spectroscopy. Absolute reflectance values are highest for the grinned samples before the experiment. For samples J3-2 and KG1-3 spectral slopes outside the crater are smaller than those inside, on the wall and before the impact (grinned material). This is most likely due to material roughness. Smoother samples seem to have smaller spectral slopes. amples J3-2 and KG1-3 show more pronounces and wider absorption bands in the spectra after the impact. For KG1-3, the absorption band around 1 micron was shifted towards shorter wavelengths. Preliminary measurements on the J3-2 and KG1-3 rocks also show fractionation and melts in J3-2 and KG1-3 samples.

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