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How are the bubbles formed in the fusion crust?

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Abstract

Fusion crust is developed on the outermost part of an object entering a planetary atmosphere by melting this object due to heating induced by hypervelocity collisions with air molecules. Vesicles (bubbles) are the most characteristic features of stony meteorites' fusion crust. There is a hypothesis that they are formed by "exsolution of volatile components from the silicate melts" due to high temperature [1]. We try to explain the mechanism of vesicles formation by counting the number of vesicles per area (the "level of vesicularity"), and checking if it correlates with the content of volatile elements in bulk composition and the numerical simulation of melting cosmic object during entering into atmosphere.

1. Introduction

Cosmic objects entering a planetary atmosphere, reach a very high temperature, as a result of hypervelocity collisions with air molecule. The outermost part of the objects is completely melting and during cooling is transforming to glassy layer, usually between 100 mm and 1000 mm thick, named fusion crust [1]. The most characteristic features of stony meteorites' fusion crust are vesicles. On the microscope images they looks like round empty objects with different size and density. There is a hypothesis that they are formed by "exsolution of volatile components from the silicate melts" due to high temperature [2].

The aim of this project is to explain the mechanism of vesicle formation within the fusion crust of eucritic meteorites (achondritic stony meteorites of basaltic composition, likely originating from asteroid Vesta-4). Completion of this study will improve understanding of interaction of bolides with the atmosphere, and determine the amount of volatiles delivered to past and present atmospheres of terrestrial planets by flux of cosmic particles.

1.1 Level of vesicularity

In order to determine the mechanism of vesicles formation it is necessary to quantitatively determine the „level of vesicularity" of the fusion crust. In order to do so we developed a Matlab code that is identifying vesicles on the SEM images and automatically calculates simple statistic of these objects (number, size, percent occupied area, etc.).

The first step of the algorithm is to determine the boundary of the fusion crust. In the SEM images the boundary of the crust is not easy to trace, but it can be distinguished automatically by four steps presented on Figure1.

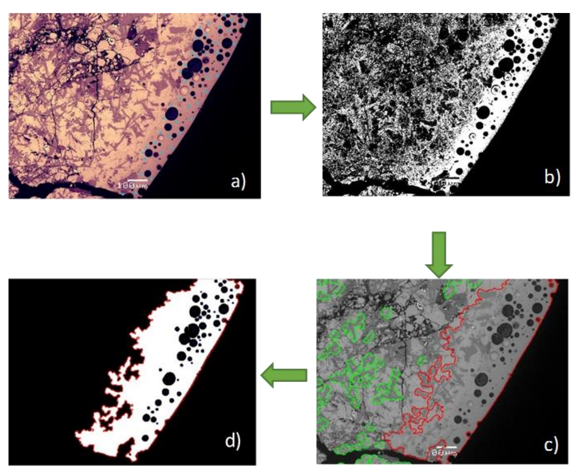

Figure 1: a) selecting pixels from the melted zone and collecting its value, b) finding the higher density of the pixels with specific range of value, c) define the boundaries of areas with high density of pixels, d) selecting the fusion crust area and separating it from the picture in order to further analysis.

The developed program was used to quantitatively determine the „level of vesicularity" of the fusion crust of the fragment of meteorite PCA91007.32 (Table 2).

Table 1: Statistical analysis of the vesicles in fusion crust of fragment of meteorite PCA91007.32 presented on Figure 1.

the number of vesicles	**49**
percentage of vesicles in fusion crust [%]	7
median of vesicles radius (M) [mm]	9
percentage of vesicles with radius > M [%]	12
percentage of vesicles with radius < M [%]	41

1.2 Volatile elements

In order to correlate the occurrence of vesicles with specific chemical components (especially volatile S) in bulk meteorite, microprobe analysis of three meteorites was performed. For this purpose selected the representative area of the bulk meteorite and analyzed the chemical components of 25 points on it, distributed like on the Figure 2.

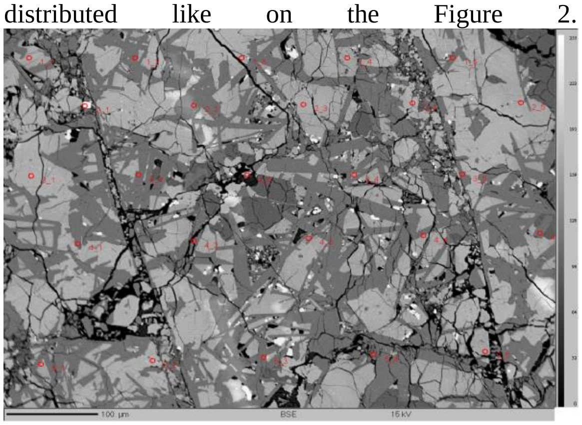

Figure 2: Reprezentative area of the bulk of the meteorite PCA91007 and points distribution for chemical component analysis.

The average contents of volatile element S in different bulk of meteorites are presented on Figure 3.

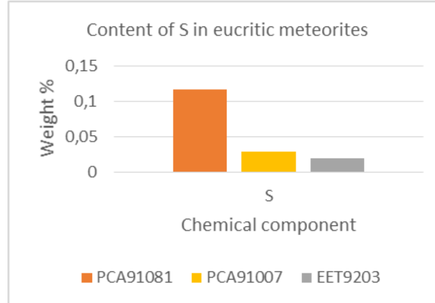

Figure 3: The average content of volatile element S in bulk of the eucritic meteorites.

It was observed the differences between the chemical composition of the eucritic meteorites, and textural of the fusion crust and the parameters of vesicles within it as well (Figure 4).

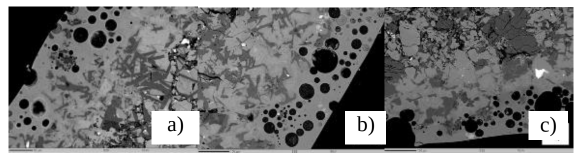

Figure 4: Comparison between textural and number of vesicles in fusion crusts by SEM images of eucritic meteorites: a) PCA91081, b) EET9203, c) PCA91007

The correlation between volatile element S and present vesicles in the fusion crust will be presented on poster session during conference.

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References

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