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IDENTIFYING FUSION CRUST AND STATISTIC ANALYSIS OF VESICLES ON SEM IMAGES

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Introduction

Cosmic objects entering a planetary atmosphere, reach a very high temperature, as a result of hypervelocity collisions with air molecules. As a result, the outermost part of the objects is melting and later transforming to a glassy layer, usually between 100 μm and 1000 μm thick, named a **fusion crust** [1]. The most characteristic feature of the stony meteorites' fusion crust is the occurrence of **vesicles.** On the microscope images they look like round empty objects. They are probably 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). In order to determine the mechanism of vesicles formation it is necessary to first quantitatively determine the „level of vessicularity" of the fussion crust. Because of this 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.).

Developed Solution

Identify the boundary of the fusion crust

The first step of the algorithm is to determine the boundary of the fusion crust. On the SEM images the boundary of the crust is not easy to trace, but it can be distinguished automatically by: **1)** selecting pixels from the melted zone and collecting its value (fig. 1), **2)** finding regions of higher density of the pixels with specific range of value (fig. 2), **3)** defining the boundaries of areas with high density of pixels (fig. 3), **4)** selecting the fusion crust area and separating it from the picture in order to further analysis (fig. 4).

Statistical analysis of the vesicles

Program recognizes the round-shaped objects present in the identified fusion crust (fig. 4). For appropriately round objects, their position and radius are determined as the vesicles parameters. Obtained parameters are used for a simple statistical analysis. Such properties as the numer, total volume, as well as the radius distribution of vesicles, can be calculated. As a output data program generates the boundary of the fusion crust (red line) and marks centers (blue points) of the vesicles.

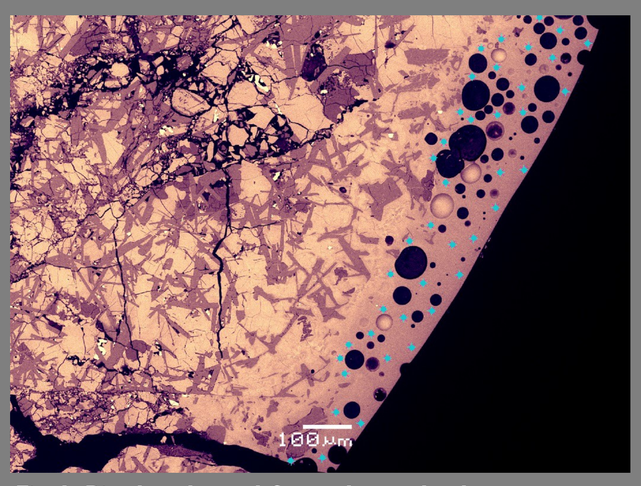

Fig. 1. Pixels selected from the melted zone

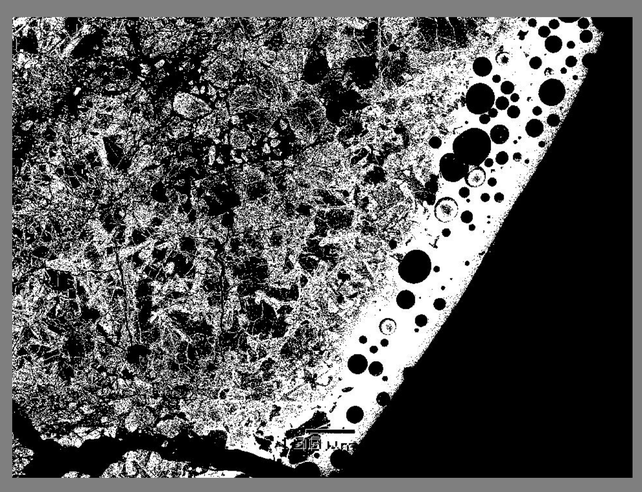

Fig. 2. Higher density of the selected pixels

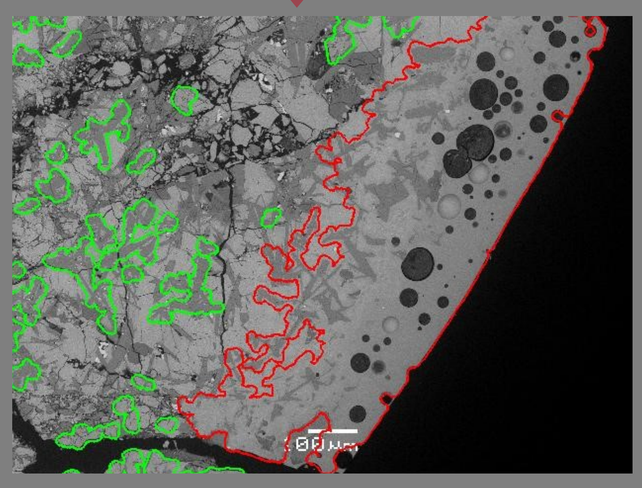

Fig. 3. Boundaries of zones with higher density of the selected pixels

Fig. 4. Separated fusion crust with identified vesicles

Results

The developed program was used to quantitatively determine the „level of vessicularity" of the fusion crust of the meteorite PCA91007.32.On the figure 5, the different parts of the same analyzed sample are presented. Identified fusion crust was separated from bulk meteorite and for this area statistical analysis for vesicles was performed. The results are summarized in table 1. The program for SEM images analysis is able to determinate the fusion crust area of the various meteorites. Nevertheless, to get a reliable results it is necessary to set the same properties during samples imagine preparation. Additionally, areas of the fusion crust selected for the statistical analysis, should not contain areas damaged by the sample preparation.

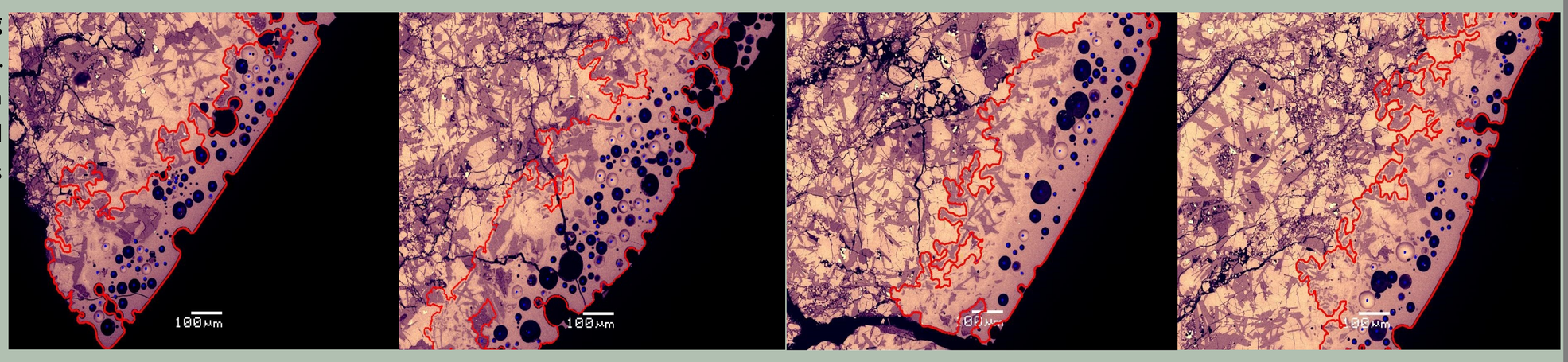

Fig. 5. Boundary of the fusion crust (red line) and vesicles (blue point) identified by developed Matlab code

Tab. 1. Statistical analysis of the vesicles in fusion crust of meteorite PCA91007.32

the number of vesicles	90	121	49	66
percentage of vesicles in fusion crust [%]	21	21	7	14
median of vesicles radius (M) [μm]	12	7	9	13
percentage of vesicles with radius > M [%]	3	3	12	12
percentage of vesicles with radius < M [%]	48	17	41	47

Future work

The future researches will consist of improving the algorithm for determining level of vesicularity, statistical analysis of vesicles in fusion crust in other eucrite meteorites and correlate they occurrence with specific chemical components in bulk meteorite.

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References:

[1] Thaisen. K. G. and Taylor L. A. 2009 *Meteoritics & Planetary Science* 44:871–878.

[2] Genge M. J. and Grady M. M. 1999, *Meteoritics & Planetary Science* 34:341-356.