EPSC Abstracts
Vol. 6, EPSC-DPS2011-501-1, 2011
EPSC-DPS Joint Meeting 2011
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Chronology and Cratering at Vesta: First Results from Dawn's Survey Orbit

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Abstract

In early August 2011 the Dawn spacecraft enters its Survey Orbit about Vesta to start a one year long mapping mission utilizing four science experiments. We will present our methods and results of preliminary age determinations of some of the major surface units of Vesta based on imaging data of the Framing Camera Experiment.

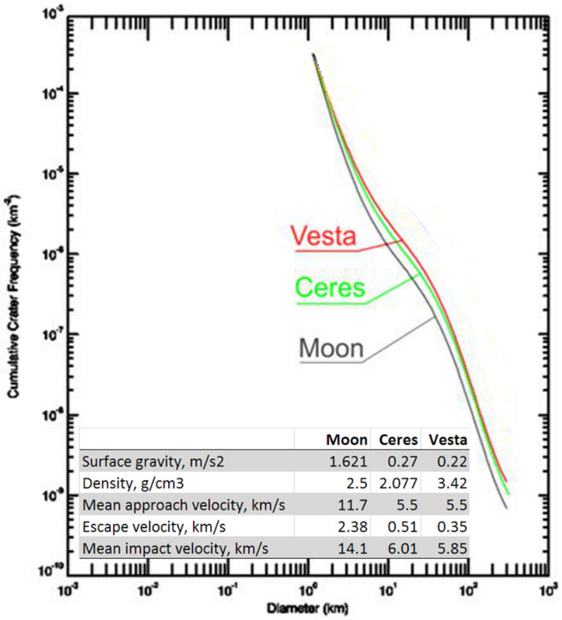
1. Introduction

The processes of the early solar system are supposed to be unravelled by the 2007 launched Dawn mission [1]. The Dawn spacecraft is supposed to enter a 2500 km orbit about Vesta in early August 2011 [2]. This high orbit results in a relatively low image resolution of the Dawn Framing Camera of about 240 m/pixel (after [1]). But this is already sufficient to do initial age determinations of the large surface units on Vesta.

2. Methods

2.1. Crater Size - Frequency Distribution

For age determinations on Vesta we use a method based on [3]. This technique requires the knowledge of the impact crater size - frequency distribution (SFD) on Vesta as well as Vesta's chronology function. High resolution imaging data is not available at the time of writing this abstract. Thus, we modeled the crater SFD of Vesta from the thoroughly investigated lunar impact crater SFD by utilizing scaling laws [4]. Since Vesta is not as massive as the Earth's moon it's surface gravity is lower, resulting in larger craters if compared to a similar impact on the lunar surface. On the other hand the impact velocity on Vesta is much lower (~5 km/s; [5]) than on the Earth's moon (~14 km/s; [3]), resulting in smaller craters. To handle these and other differences in the impact properties the application of scaling laws is mandatory. Figure 1 shows the modeled crater SFDs of Vesta and Ceres, the second target of the Dawn mission.



	Moon	Ceres	Vesta
Surface gravity, m/s2	1.621	0.27	0.22
Density, g/cm3	2.5	2.077	3.42
Mean approach velocity, km/s	11.7	5.5	5.5
Escape velocity, km/s	2.38	0.51	0.35
Mean impact velocity, km/s	14.1	6.01	5.85

Figure 1: Modeled crater size - frequency distributions of Vesta and Ceres in comparison to the lunar crater SFD.

In general, the formation of small craters is governed by the strength regime, while large craters are governed by the gravity regime [4]. Therefore, Vesta's SFD for small craters is similar to the lunar crater SFD but at larger crater sizes the crater SFD of Vesta becomes shallower than the lunar SFD, because of the lower surface gravity. Since the transition crater diameter from the strength to gravity regime is unknown, the presented crater SFD of Vesta might differ somewhat from our initial measurements of Vesta's crater SFD. The same applies for the transition crater diameter from simple to complex cratering.

2.2. Chronology Function

The chronology function of Vesta (Figure 2), which is also required for age determination, can be modeled from impact probabilities derived from statistical analysis of the orbital elements of 30 km and larger bodies inside the asteroid Main Belt [6].

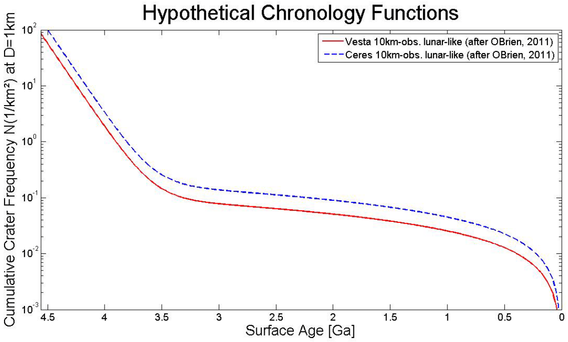


Figure 2: Hypothetical lunar-like chronologies for Vesta and Ceres.

The impact rate for 30 km projectiles has to be converted into crater sizes (~240 km on Vesta) by the scaling laws mentioned. The crater SFD gives the ratio of crater frequencies between 240 km and 1 km diameter craters. In this way we estimate the expected formation rate of 1 km craters. The integration over time of the formation rate of 1 km craters gives the chronology function. Our initial measurements already suggest that we have to use a lunar-like chronology [3] with an exponential decay before about 3.5 Ga rather than a linear chronology.

3. Summary

At the time of writing this abstract there are only preliminary cratering measurements available from the Dawn mission. The here presented crater SFDs and chronology functions are the pure result of modelling. At the conference we will present a crater SFD for Vesta, which is improved by actual cratering measurements from the Dawn survey orbit as well as a chronology function which will also be improved based on our initial cratering measurements.

Acknowledgements

This work was supported by the German Space Agency (DLR) on behalf of the Federal Ministry of Economics and Technology, grant 50 OW 1101.

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