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Secondary Crater Size - Distance Relationship on Ceres

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Abstract

Ceres shows an exceptionally high density of secondary craters. We investigate the relationship between the secondary crater size, their corresponding distance from the source crater and the impact velocity of the secondary projectiles for the example of Yalode crater secondaries. For our investigation we use Dawn FC imagery and a crater ejecta model.

1. Introduction

Ceres is the largest and most massive object in the main asteroid belt which is classified as dwarf planet. This object has been investigated from 2015 to 2018 by NASA's Dawn mission [1]. High resolution imaging data [2] of Ceres reveals a densely cratered surface including an unusually high fraction of secondary craters. We model the ejecta distribution pattern and analyse the secondary projectile flightpaths under consideration of Ceres' rapid rotation. Previous work [3,4] has shown that our approach is able to accurately model existing global color ratio deviations as well as tracing back secondary crater chains to its source crater. In the present work we will use the model prediction for impact velocities of secondary projectiles of the Yalode crater in order to deduce a relationship between the size of a secondary crater, the impact velocity of its respective secondary projectile and the travelled distance of the particular secondary projectile.

2. Data

For our measurements we use the Samhain Catenae surface feature that previously was interpreted as a system of pit chains [5]. Since the spatial orientation of Samhain Catenae aligns very well with the trajectories of our Yalode modelled crater ejecta (Fig. 1) we hypothesize Samhain Catenae as secondary crater chains of this crater. Thus, the width of the Catenae would reflect the secondary crater diameters. The impact velocities as well as distances between the ejection and impact points of the secondary projectiles are taken from our ejecta model. Table 1 list our preliminary measurements for the most north-eastern groove of Samhain Catenae. Fig. 2 shows the resulting plots of our measurements.

Table 1: Flight distance – impact velocity – secondary crater size relationship for the most north-eastern groove of Samhain Catenae on Ceres.

Flight Distance [km]	Impact Velocity [m/s]	Secondary Crater Size [km]
187	197	14.6
209	215	12.4
230	218	11.2
358	275	6.4
420	270	8.8
451	268	9.6
548	311	6.2
596	324	6.5

3. Results

Our results (see Tab. 1) shows the general trend of smaller secondary craters with increasing distance and increasing impact velocity. These trends are expected in a general picture where large secondary projectiles are ejected at low velocities and thus only fly short distances and smaller projectiles are accelerated to higher velocities and thus impact further away. However, given the higher impact velocities for further flying projectiles it would be reasonable to assume a change in crater scaling, where the crater-to-projectile diameter ratio is increasing. In fact higher impact velocities of far flying projectiles appear to increase the secondary crater depth-to-diameter ratio [6]. More systematic work is required for a better understanding of Ceres' secondary crater population.

References: [1] C. T. Russell, et al., *Science*, *353*, 1008 (2016). [2] H. Sierks et al. (2011) *Space Science Reviews*, *163*, Issue 1-4, pp. 263-327. [3] N. Schmedemann et al. (2018) *LPSC*, *49*, Abstract 2083. [4] N. Schmedemann et al. (2018) *EPSC*, *12*, Abstract EPSC2018-998. [5] J.E.C. Scully et al. (2017) Geophysical Research Letters, 44, pp. 9564-9572. [6] N. Schmedemann et al. (2019) LPSC, 50, LPIContrib.No.2132.

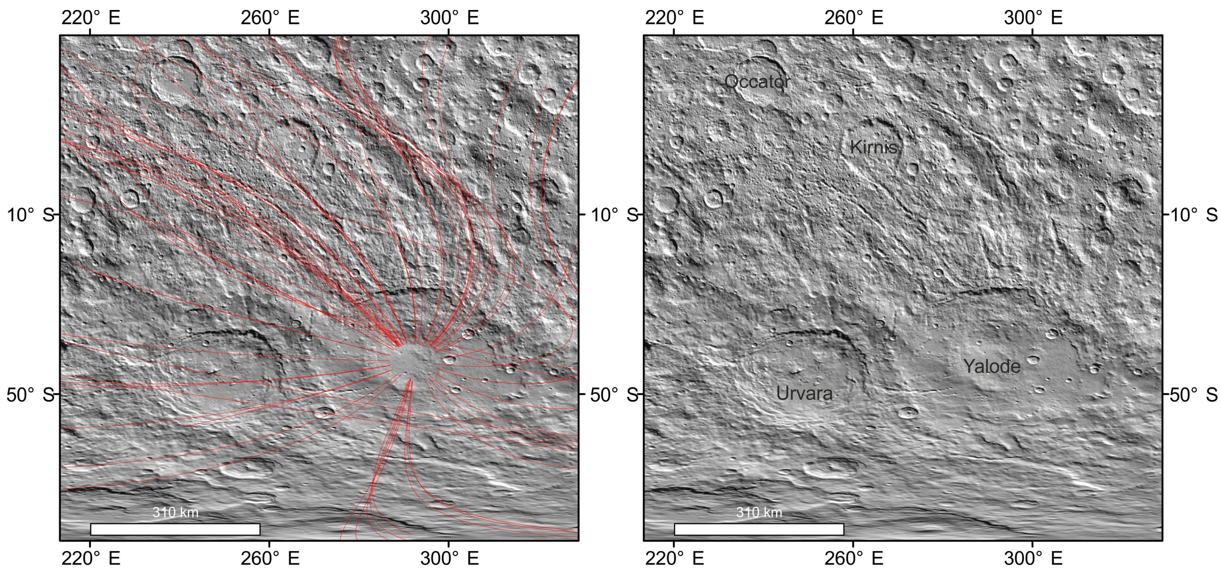

Fig. 1: Left: *Yalode ejecta trajectories for constant ejection angles of 45° with the locale surface plane. Right: Same map like on the left side with crater names and without ejecta trajectories.*

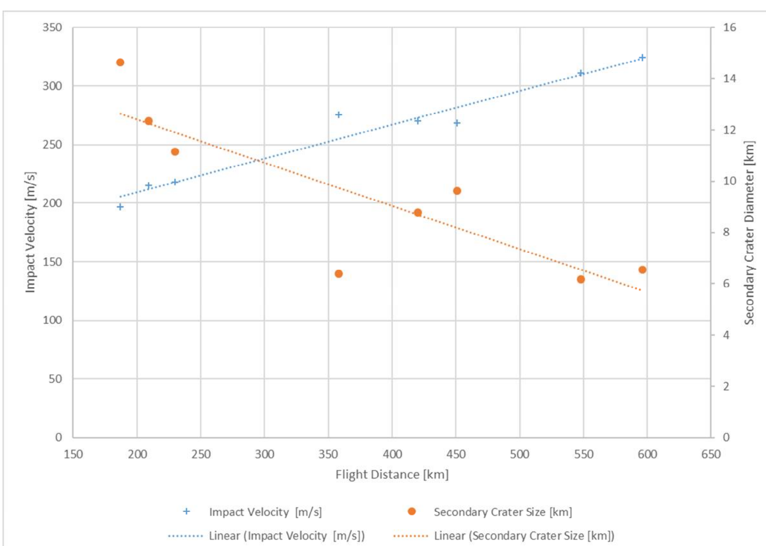

Fig. 2: *Scatter plot of impact velocity vs. flight distance and secondary crater diameter vs. flight distance. Flight distances where measured along the modelled trajectories in a Yalode centered azimuthal equidistant projection. Impact velocities were taken from the ejecta model and secondary crater diameters were measured in the map in Yalode centered azimuthal equidistant projection.*