THE SIGNATURE OF SECONDARY CRATERING ON 4 VESTA AND TETHYS.

N. Schmedemann[1], T. Kneissl[1], A. Neesemann[1], G. Michael[1], R. J. Wagner[2], C.A. Raymond[3], C.T. Russell[4], [1]Institute of Geological Sciences, Freie Universität Berlin, Berlin, Germany, [2]German Aerospace Center, Institute of Planetary Research, Berlin, Germany, [3]JPL, Caltech, Pasadena, CA,USA, [4]University of California, Los Angeles, CA,USA (nico.schmedemann@fu-berlin.de)

Introduction: Recently the Main Belt Asteroid Vesta has been investigated and mapped by the Dawn mission [1]. One of the many goals of the mission was to investigate the cratering record of that asteroid and derive its cratering history. Since 2004 in orbit about Saturn the Cassini spacecraft is pursuing a similar goal for the icy satellites of the Saturnian System with its imaging science sub-system (ISS) experiment [2]. Comparisons have been made between Vesta and the saturnian icy satellites with respect to basin morphology [3] and the possibility of the occurrences of secondary craters [4]. Indeed there are similarities in size and surface gravity between Vesta and some of the icy satellites. However, there are also significant differences such as the composition of those bodies, which could influence crater scaling. It was concluded in previous work [4,5] that on Vesta and Tethys secondary craters can form but not on Mimas whose escape velocity is lower than the minimum velocity to form secondary craters. In this work we compare measured crater populations from all three bodies with indications for secondary craters on Vesta and Tethys.

Methodology:

Production Function: The crater production function for Vesta is scaled from the Moon to the impact conditions on Vesta, following [6]. The crater production function for Mimas is derived from several different measurements on Mimas, which have been vertically normalized to each other following an approach by [7].

Software: For the mapping task we used ESRI ArcGIS mapping software together with the CraterTools [8] plug-in. This tool allows for map-projection independent measurements, which increases reliability of measured crater sizes. Crater statistics were generated and analyzed with the craterstats software [9]. In addition, we performed randomness analyses of the spatial crater distribution [10].

Imaging data: For Vesta we used imaging data of the Dawn Framing Camera [11]. Crater counts on Mimas and Tethys were performed utilizing Cassini ISS imaging data [4].

Results: We measured the crater size-frequency distribution (SFD) on Vesta at several locations in the heavily cratered northern hemisphere and in the Rheasilvia Ridge and Groove Terrain [12]. Several measurements (only one is shown here for clarity) of large parts of the northern hemisphere of Vesta show clearly a steeper crater SFD in the range of usually between ~7 and 12 km than we observe in the younger Rheasilvia Ridge and Groove Terrain (also just one example of several more). In Fig.1 we vertically normalized the two measurements to each other at about 12 km diameter for better comparability. While the measurement in the Rheasilvia Ridge and Groove Terrain follows the lunar-like production function for Vesta between about 2.5 and 30 km, the crater SFD of the measurement in the northern hemisphere shows a very steep characteristic between ~7 and 9 km crater diameter. The termination of the steep distribution at 7 km is not immediately expected from a secondary crater distribution but may be explained by the very high crater frequency, which possibly shows saturation effects at 7 km and smaller crater diameters respectively.

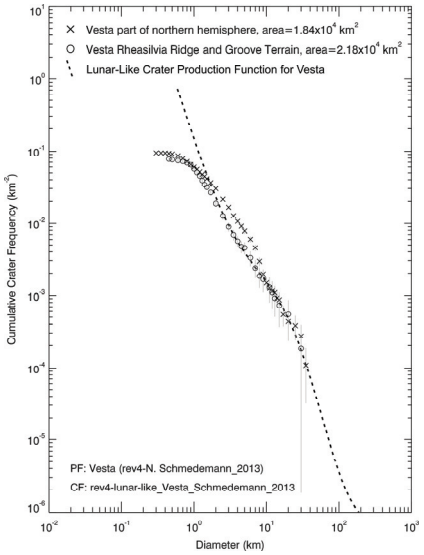

Fig.1: *Crater SFD of two areas on Vesta, vertically normalized to each other at ~12 km. The measurement in the northern hemisphere shows a much steeper distribution between 7 and 9 km diameter.*

Fig.2 shows an example of a possible secondary crater chain on Vesta. It is about 8 km wide and strikes roughly in N-S direction. It is not aligned with the Veneneia basin whose closest part of the basin rim is located about 250 km SE of the crater chain. If the chain would have been formed by Veneneia secondaries, the younger Rheasilvia ejecta and secondaries would have obscured the chain afterwards. Thus, it

appears more likely that this chain formed by Rheasilvia secondary projectiles.

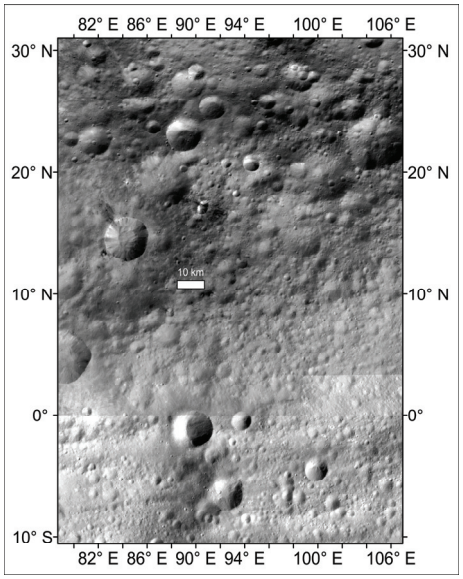

Fig.2: *A possible secondary crater chain formed by Rheasilvia secondary projectiles is located just right of the scale bar (10 km).*

The width of the possible Rheasilvia secondary chain and the crater size where an unusually steep crater distribution is observed in the northern hemisphere of Vesta agrees well. Thus, it appears likely, that the observed steep crater distribution in large parts of the northern hemisphere of Vesta is caused predominantly by Rheasilvia secondaries. It is possible however, that also secondaries of the Veneneia impact might contribute a fraction of the observed secondary craters. Also, re-impacting members of the collisional family of Vesta could possibly contribute similar craters although they are probably far outnumbered by background primary impacts.

On the saturnian satellite Tethys we also observe a steep distribution of craters below about 5 km diameter. In Fig.3 we compare the crater SFD of Mimas and Tethys with each other. [4] concluded that secondary cratering is possible on Tethys but not on Mimas. Thus, we use the measured crater SFD of several measurements on Mimas in order to derive an approximate crater production function for Mimas and plot the observationally derived production function together with two measurements of Mimas and two of Tethys. Although on different orbits about Saturn the measured crater SFD of Mimas and Tethys are almost identical between ~5 and 17 km. Similar to Vesta but unlike Mimas, Tethys clearly shows a steep crater distribution below 5 km diameter in one measurement, which also could indicate a secondary crater population on Tethys, if Mimas and Tethys were impacted by the same projectile population.

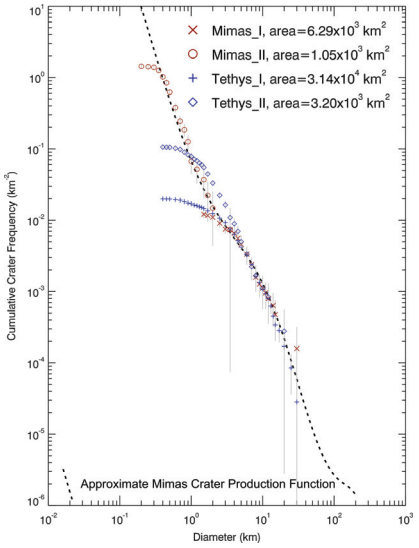

Fig.3: *Crater SFD of Mimas and Tethys superimposed with an approximate crater production function of Mimas. Tethys I and II measurements are vertically normalized to Mimas I at ~10 km. Mimas II is vertically normalized to Mimas I at 3 km crater size. Tethys II shows a steep crater distribution below ~5 km diameter, similar to the northern hemisphere of Vesta.*

Acknowledgement: This work has been supported by the German Space Agency (DLR) on behalf of the Federal Ministry of Economics and Technology, grants 50OW1101 (NS, TK, AN) and 50QM1001 (GM).

References

[1] Russell C. T. et al. (2012) Science 336, 684. [2] Porco et al. (2004) Space Science Reviews 115:363-497 [3] Schenk P. et al. (2012) Science 336, 694. [4] Bierhaus et al. (2012) Icarus 218, 602-621 [5] Bierhaus et al. LPSC (2012) 43rd LPSC, held March 19-23, 2012 at The Woodlands, Texas. LPI Contribution No. 1659, id.2451. [6] Ivanov B. A. (2001) Chronology and Evolution of Mars 96, 87–104, 2001. [7] Neukum G. and Ivanov B. A. (1994) In: Gehrels T (ed) "Hazards due to comets and asteroids". University of Arizona Press, Tucson, 359–416, 1994. [8] Kneissl T. et al. (2011) Planetary and Space Science 59, 1243-1254. [9] Michael G. G. and Neukum G. (2010) Earth Planet Sc Lett 294, 223-229. [10] Michael G. G. et al. (2012) Icarus 218, 169-177. [11] Sierks et al. (2011) Space Sci.Rev., 163, 263-327. [12] Jaumann R. et al. (2012) Science 336, 687.