

Morphological analysis of pit chains on Ceres and Europa. R. Parekh¹, E. S. Martin², G. C. Collins³, J. E. C. Scully¹, R. Pappalardo¹, M. E. Cameron¹, K. A. Otto⁴, R. Jaumann⁵, C. T. Russell⁶, C. A. Raymond¹. ¹Jet Propulsion Laboratory/California Institute of Technology (rutu.a.parekh@jpl.nasa.gov), ²Center for Earth and Planetary Studies, Smithsonian Inst., Washington D. C., USA, ³Dept. of Physics and Astronomy, Wheaton College, Norton, MA, USA, ⁴DLR Inst. of Planetary Research, Berlin, DE, ⁵Freie University, Berlin, DE, ⁶UCLA, Los Angeles, CA, USA

Introduction: Pits chains are a type of linear structure composed of circular to semi-circular collapsed pits which are partially or fully fused together to produce scalloped-edged steeply dipping troughs [1-5]. Multiple mechanisms [5] have been hypothesized to form pit chains via the sinking of the surface regolith material into a subsurface void [2, 5-12]. Therefore, a key motivation of this study is to establish a relationship between surface pit chains and subsurface properties and to derive quantitative information to understand the distribution of regolith. Ceres and Europa have relatively low surface temperatures and their subsurface is made of water ice [13-15], however, their surface regolith production and dynamics are poorly known. In this analysis, we utilized the extended data from the Dawn mission (XM02, [18]) and Solid-State Imager (SSI) camera onboard the Galileo spacecraft [19].

Ceres: On Ceres, pit chains are located on the floor of the Occator crater (diam. ~92 km, [16], n=1355 including from [16,17]). Most pit chains are densely populated in the hummocky surface of the SW region and at the center of the elevated area of Cerealia Faculae, whereas very few are located within Vinalia Faculae of Occator. Pit chains have circular to elliptical visible rims and are partially muted. The presence of individual pits is interpreted as the initial phase of chain development hence, we infer them as one of the most recently developed surface features within Occator.

Europa: Pit chains on Europa are observed within the Conamara Chaos terrain and the NE part of Agenor Linea.

Agenor Linea: The pit chains observed within the Agenor Linea (n=9) are parallel to a bright band and present within the adjacent smooth dark region. At the given resolution (46 m/px) we noted individual pits which gradually opens up forming a wider trough. Due to the close proximity of pit chains with the band and associated fractures, we suspect them to be produced by extensional faulting and/or fracturing. Similar conditions were noted on Phobos and Mars [4]. During fracture opening, isolated pits are inferred to be first formed, and continued dilation at the surface increases pit diameter via draining of regolith material into the void [2], forming elliptical to partially merged pit chains.

Conamara Chaos: Similar to Ceres, pit chains within Conamara Chaos plains (n=8), are noted within the elevated regions of hummocky terrain. The limited

resolution (9 m/px) doesn't allow the observation of isolated pits, which rather they appear to have evolved from separate individual pits to a long trough with linear edges. Unlike Agenor Linea, we do not observe any bands or fractures within the vicinity of pit chains; hence, we hypothesize that a different endogenic mechanism is involved to produce a substantial subsurface cavity to accommodate collapse of loose regolith within Conamara Chaos.

Summary: Despite Europa's young surface [15], the observed pit chains are relatively mature, where isolated pits are difficult to observe, in comparison to Ceres. On Ceres, pit chains are observed within the proximity of the large impact crater Occator which could be responsible for the production of the regolith on the surface. However, in the case of Europa, the lack of large impact craters [15] further raises questions related to the presence of regolith. Additionally, the difference in the geological and morphological conditions implies the involvement of multiple mechanisms for the formation of pit chains on Europa. Of course, the absence of pit chains within plains does not necessarily imply the absence of loose surface regolith. Perhaps, the lack of their presence may suggest the absence of potential sub-surface deformation which destabilizes the surface regolith or pit chains that have not been preserved in a particular region.

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