On the Origin of Internal Layers in 67P/ Churyumov-Gerasimenko. M. J.S. Belton[1,2], X.-D. Zou[3], J.-Y. Li[3] and E. Asphaug[4], [1](mbelton@dakotacom.net)Belton Space Exploration Initiatives, 430 S. Randolph Way, Tucson, AZ, 85716, [2] Emeritus Astronomer, Kitt Peak National Observatory, [3]Planetary Research Institute, [4]School of Earth and Space exploration, Arizona State University.

Introduction: From OSIRIS NAC images, we have investigated the dimensions and spatial trends (from center outwards) of the strata, their texture and colors, phase trends and differences, and the physical interpretation (what defines a stratum) and their relationship with surface evolutionary processes.

We present an analysis of the layered structure on 67P/Churyumov-Gerasimenko' s Hathor cliff and propose a mechanism for its origin. The Hathor cliff exposes internal layers and fracture structures that are crudely repetitive and that extend deep into the small lobe over a radial distance of ~ 650 m. We find an average radial thickness of a stratum, defined as the upper stratum boundary and the associated intra-strata material below, of ~ 40 ± 12 m and estimate the average length of each stratum at ~ 290 ± 110 m. Structures in intra-strata material are highly varied ranging from thin, often distorted, layers (~1 - 3 m thick), to block-like and globular-shaped features (typically ~1.5 m radius). Prominent, radially oriented, fractures overlying the layer structure, are typically separated by ~80 ± 30 m and are ~5 m, or less, wide. Photometric measurements and interpretations are currently being investigated.

The origin of strata and intra-strata layers: We hypothesize that the origin of the alternating upper stratum boundary layer and intra-strata material are the result of the passage of vertically, self-propagating amorphous-to-crystalline ice phase-change fronts into the interior of the comet during its late-stage orbital evolution as a Centaur. If this is a viable mechanism, the interior layered structure must be geologically young (~106 y). Guided by the results of calculations by Tancredi, Rickman and Greenberg (1994, Astron. Astrophys. 286, 659 – 682) on the dual-mode propagation of such fronts in a simulated comet nucleus, we propose that the bi-modal rates of propagation of these fronts (an essentially stationary 'quiescent" mode alternating with an "active" rapid spurt mode propagation (~100 m/y) over much larger distances) leads to the establishment of alternating strata boundaries and the intra-strata material. The varied structures found in the intra-strata material are the result of different modes of fluidization of the material caused by the rapid release of CO during the active propagation phase. In this scenario, prominent radially aligned fractures were formed after the layers were established as a result of extensional stress due to CO and other super-volatile gases released during the phase-change process. The independence of the layer systems in the two lobes (Massironi and 58 colleagues. 2015. Nature 526, 402 – 405) is explained by the postulated break-up of the nucleus from a bi-lobate shape into a low energy, close binary, at the time of onset of crystallization that weakens the surface. Eventually, the comet returns to a physically connected bi-lobate shape well after the crystallization of the interior of both lobes is complete (in about ~2000 y). This "phase-change mechanism" may eradicate any evidence of the way the nucleus was originally formed in primeval times.

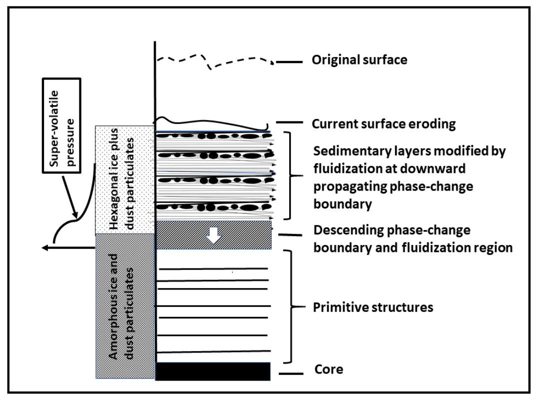

Figure 1. (Cartoon not to scale) One of the phase change front descending into the interior. The width of a typical front is ~ 290 m and its Its thickness ~ 10m.

References:

[1] Belton M. J. et al. On the Origin of Internal Layers in Comet Nuclei. in prep. [2] Massironi, M., and 58 colleagues. 2015. Nature 526, 402-405.. [3] Tancredi, Rickman and Greenberg (1994), Astron. Astrophys. 286, 659 – 682.