**EVIDENCE FOR LARGE-SCALE HETEROGENITY IN CERES' SUBSURFACE.** C. A. Raymond[1], S. Marchi[2], M. T. Bland[3], J. C. Castillo-Rogez[1], R. S. Park[1], C. T. Russell[4], K. Hughson[4], [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, (carol.a.raymond@jpl.nasa.gov), [2] Southwest Research Institute, Boulder, CO, [3]USGS Astrogeology, Flagstaff AZ, [4]UCLA, Los Angeles, CA.

**Introduction:** The Dawn mission arrived at Ceres in March 2015 to find a body quite different than expected. Previously, shape and density estimates derived from HST observations [1] were interpreted to indicate that volatiles had separated from the silicates within Ceres, leaving a differentiated interior. Thermal evolution models [2, 3] further predicted that a subsurface ocean would have been present on Ceres during some part of its evolution, raising the enticing possibility of Ceres being a habitat for life in the early solar system. However, the degree of differentiation was not well-constrained from the pre-Dawn data, and in fact it had been argued that Ceres was an undifferentiated object [4].

**Did Ceres Differentiate?:** Upon arriving a Ceres, Dawn found that Ceres was slightly smaller (avg radius of 470 versus 476.2 km, [5, 6]), flatter and denser [5] than the previous estimates, raising the question of how completely Ceres had differentiated. The degree-2 gravity measured by Dawn indicates Ceres is close to hydrostatic equilibrium and the inferred moment of inertia indicates some degree of central condensation [5], suggesting a gradient in the content of volatiles across the interior. In addition, the surface was found to be heavily cratered indicating that the outer shell was not dominated by ice, as expected for a differentiated body [7]. Crater preservation at all scales, absent those larger than ~300 km [7] and complex morphology of the surface indicate a strong outer shell comprising no more than 40% ice by volume [8, 9]. The global, near-hydrostatic shape is consistent with a warmer, weaker interior [9] beneath the strong outer shell. While the lack of evidence for an ice-dominated layer near the surface could indicate that it never formed and thus Ceres only partially differentiatied; an alternate explanation is that the ice-rich outermost shell was lost as a result of impacts and to mixing of the ice with the silicate-rich briny layer that formed at the base of the former ocean [10].

**Heterogeneity in Ceres' Outer Shell:** Understanding the composition and rheology of the outer shell is a key part of solving the interior evolution puzzle. Thus far, we see evidence in the crater record for a viscosity several orders of magnitude higher than pure water ice [8]; however, the crater preservation state varies considerably over the surface. There is no striking latitude dependence to the variation in crater preservation state, rather there are regional and local variations that juxtapose smooth, apparently relaxed or resurfaced areas (e.g., Kerwan crater and surrounding areas) next to areas of well-defined impacts and tectonic features. At a local scale, the twin neighboring craters Coniraya and Vinotonus show very different depths, possibly reflecting a discrete local variation in the ice content within the subsurface, as discussed by [8]. The largest craters Kerwan and Yalode are associated with surronding smoother, more sparsely cratered terrains, as shown in Fig. 1, and show smooth interiors with subdued or degraded rims,(Fig. 2).

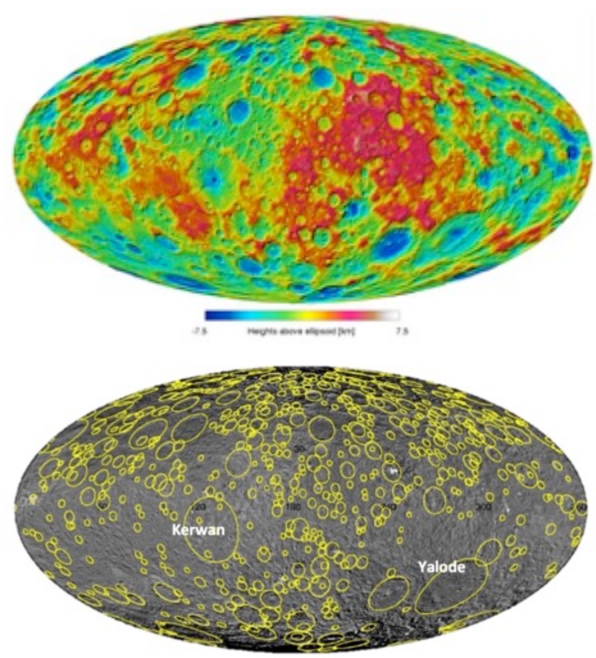


**Figure 1.** *Top: Color-contoured global DTM of Ceres relative to a 482x446 biaxial ellipsoid. Bottom: Global distribution of craters larger than 20 km in diameter from [7].*

**Implications:** The regional scale variations in roughness and cratering could be caused by variability in the viscosity of the volatile-rich shell, or could reflect a resurfacing process. Indeed the possibility for cryovolcanic activity is suggested by the Ahuna Mons [11]. In either case, craters could be erased and smooth terrain created. However, these two processes would yield differences that would help distinguish one from the other. In the case of relaxation, the degree of crater obiliteration would be a function of crater size and age, and possibly would vary with latitude (temperature). If caused by resurfacing, the crater size frequency distribution would be similar to but offset with respect to that of the surrounding terrains. Such behavior is observed in the Kerwan region [7]. In addition, some correlation is seen between variations in the visible spectrum [12] and the areas of smooth terrain. Both hypotheses are under study. In either case, relaxation or resurfacing would indicate an internal process that resulted in primordial heterogeneity (possibly degree-one convection [13]) in the volatile-rich shell, or subsequent convective processes that drove regional resurfacing.

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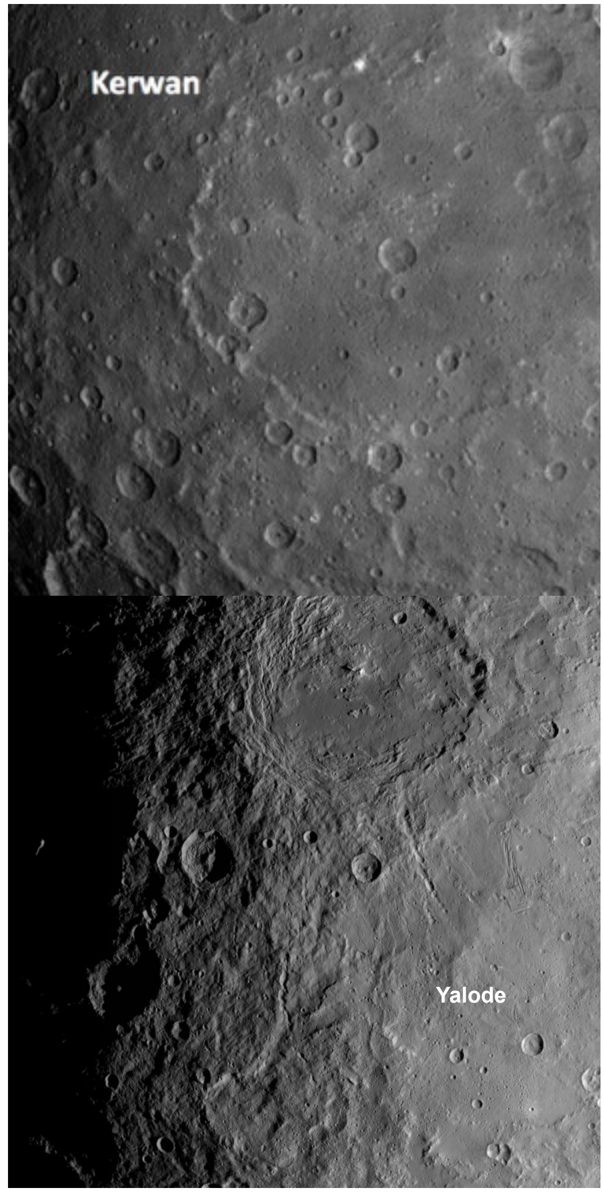


**Figure 2.** *Images of the region around Kerwan crater (top) and Yalode crater (bottom).*