A DEEP IMPACT MISSION CONTRIBUTION TO THE INTERNAL STRUCTURE OF JUPITER FAMILY COMETARY NUCLEI: THE TALPS OR "LAYERED PILE" MODEL.

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Introduction: We propose that the wide spread layering observed on the surface of 9P/Tempel 1 (Fig. 1) during the Deep Impact mission [1, 2] and seen with less spatial resolution as mesas and irregular flat bottomed depressions on 81P/Wild 2 [3] and mesas on 19P/Borrelly [4] is an essential element of the internal structure of most Jupiter family comet nuclei. Topographic features on the surface of 1P/Halley [5] are too poorly resolved to be sure that such layering is present on its nucleus and so we cannot confidently include Halley family or Oort cloud comet nuclei in this analysis. We suggest that this layering is the natural outcome of low velocity collisions with other primitive Kuiper Belt bodies that must have occurred during the late accumulation stage of these objects in the solar nebula [6]. In this picture the layers were laid down over 10^5 – 10^6 yr [6] and some may have had very short exposure time to the nebula environment. This may be the reason why two of the observed layers (smooth terrains [2]) appear to geologically young. Nevertheless, there is room in the model for two types of layers, one priordial and the other the result of a recent geologic process [2].

The model: Based on this proposal, a structural model for the interior, called here the Talps or 'layered pile' model, is presented for typical Jupiter family comet nuclei that has an inner core transitioning to an outer mantle consisting of a sequence of thin, randomly stacked, layers, each of limited area and, possibly showing small differences in composition, out to the surface. As presented here this model predicts a correlation between the radial distance and the average thickness of the layers. As long as gravity plays a minor role large nuclei are expected to have thicker surface layers and vice versa.

Mesas are formed, following the suggestion by Britt *et al.* [4], as a result of erosional sublimation at the boundaries of the outermost layers during passages near the sun. Cometary splitting and tidal disruption is seen as the result of detachment of entire layers or, possibly, disassembly of essentially the entire, presumably weakly bonded, layer structure.

This model is related to the original primordial rubble pile model of Weissman [7] but is distinct from it since rather than being a loose accumulation of primordial bodies and collision fragments that largely retain their individual structures, the accumulating nebula condensations are grossly distorted in the low velocity collisions and effectively flow onto the surface of the growing nucleus; the structure is more like a pile of layers (Fig. 2). We visualize this layering process as analogous to the behavior seen in the relatively higher velocity collisions of small dust aggregates in the laboratory by Wurm *et al.*[8].

For the layer structure to be retained over a large fraction of the age of the solar system, the nuclei of the Jupiter family comets are unlikely to be individual fragments produced in collisions or collections of such fragments as envisioned by Davis and Farinella [9]. Except for stratified evolution of a thin boundary layer at surface under the influence of the sun and, possibly, thermal alteration of the core [10] the organization of the layers in the interior should be primordial. Because of the relatively severe collisional environment in the classical Kuiper belt [9] and the expected sensitivity of the layered structure to collisional disruption, Jupiter family comets, or at least most of them, most likely originate in the scattered disk where the long term collisional environment may be more benign as suggested by Rickman [11]. That the scattered disk is the source of most Jupiter family comets has earlier been argued on dynamical grounds by Duncan *et al*. [12].

Predictions: This model makes definite predictions for the outcome of certain experiments on the *Rosetta* mission at 67P/Churyumov-Gerasimenko. In particular, the CONSERT experiment [13] should, providing its spatial resolution is adequate, be able to detect layering deep into the interior and and possibly map the predicted reduction of mean thickness of the layers with depth and possibly detect a transition to an inner core structure, The OSIRIS Camera [14] should find widespread geological evidence of the same kind of layering as seen at 9P, 19P and 81P since 67P has approximately the same effective radius [15]. *This research was funded by NASA through the Deep Impact Project*

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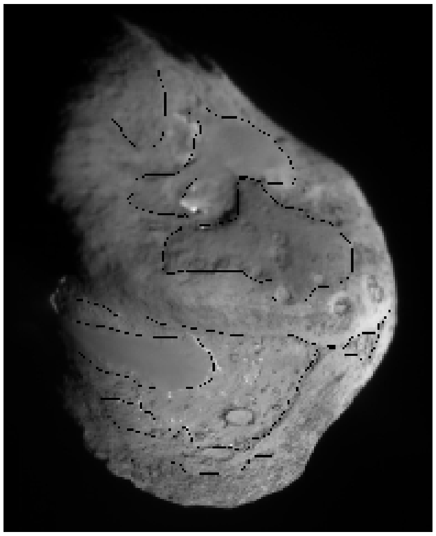

Fig. 1. 9P/Tempel 1 with apparent layer boundaries roughly marked. As many as seven layers may be present.

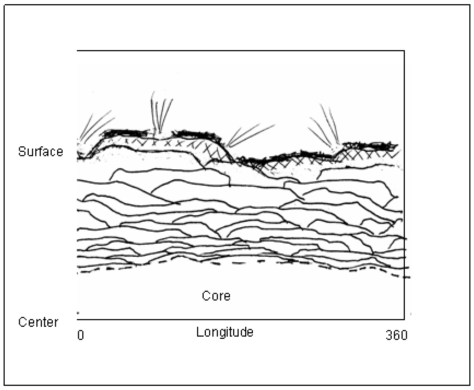

Fig. 2. Cartoon of the radial structure of a cometary nucleus according to the Talps or 'layered pile' model. The plane of the section passes through the center of the object. The layer boundaries are shown and are meant to represent the boundaries of material laid down by a major accumulative collisions. Near the center the layers transition to a possibly thermally modified core of unknown extent. At the surface the cartoon depicts a thin lag deposit occasionally disrupted especially at the boundaries of specific deposits where sublimation can preferentially take place. Immediately below is a region in which compositional stratification may have taken place.