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Layering and internal structure of the comet 67P/Churymov-Gerasimenko as observed by ROSETTA

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Abstract.

The peculiar bi-lobate shape of 67P/Churyumov-Gerasimenko (67P/CG) has soon raised the question if it is the expression of two distinct objects or the result of a well-localized excavation on the neck region in-between the two lobes. The 3D reconstruction of the widespread layering involving most of 67P/CG surface seems to give an unambiguous answer to this topic. Here we will show how layering, pervasively dissected by fracture systems, can be used to infer part of the internal structure of the comet providing evidence that the two lobes are characterized by hundreds-of-meters-thick-layered sequences and are indeed independent objects. In particular, we have reconstructed 10 geological sections deriving strata orientations from best fitting planes of cuesta dorsa and terraces retrieved from a stereo-photoclinometric shape model of the comet

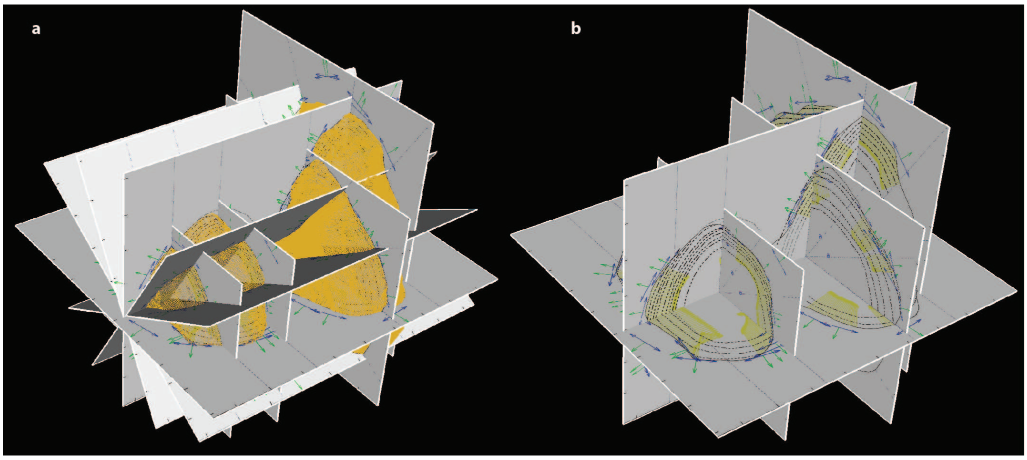

Fig. 1. a) Point cloud of the photoclinometric shape model of 67P/CG comet (Jorda et al. submitted) transected by 10 cross-sectional sliced used to realize the geological sections in Massironi et al. 2015. b) Perspective view of five geological sections of 67P/CG comet. Blue: best-fitting planes; green arrows: vectors perpendicular to each best-fitting plane (i.e. vectors of the strata plane); yellow: field of lines used for drawing layers within the comet nucleus (layers are perpendicular to the yellow lines); dashed black lines: layers.

nucleus (3.6 million facets at 6 m sampling; Jorda et al. 2015). The geological sections, realized along and perpendicular to the major axis, unequivocally show independent onion-like stratified structure of the two lobes (figure 1, Massironi et al. 2015). In addition we have retrieved the angular deviation from perpendicular of the strata planes with respect to the local gravity vector calculated for the entire comet or the two separated lobes (Massironi et al. 2015). In figures 2 the angular relationship between the strata and the gravity field vectors are visualized through stereographic projections. Stereographic projections readily describe statistics of the orientation of planes cutting a given topographic surface and has been recently applied on minor bodies (Buczkowski et al. 2008; Besse et al., 2014). Here we adopted a relative frame system based on the local gravity vector (whose pole is at the center of the stereographic projection) (for further details on stereographic projections on a relative frame see Simioni et al. 2015).

In particular, in figure 2 we can see how the strata poles (i.e. strata plane-normal vector) are coincident or very close to the local gravity vectors if the two lobes are considered as two separate objects, and they consistently depart from parallelism if the gravity field of the entire comet nucleus is taken into consideration. By relating the angular deviation of each strata pole to the local gravity vector with respect to its distance from the neck region (comet nucleus center), we can also see that the angular deviations increase towards the neck region when considering the entire comet nucleus (fig. 2a) and are lower and unrelated to the distance from the neck in the case of two separated objects (fig. 2b). In summary we have three strong lines of evidence suggesting that the layered envelopes of the two lobes had to be formed independently and before their aggregation: i) the orientation of strata across the neck region does not match between the major lobe (called ”main body”) and the minor one (called head), ii) the geological sections of the inner comet nucleus show two distinct envelopes (fig. 1), iii) the local gravity vectors calculated for the two separated objects (i.e. the main body and the head) are closer to perpendicular to the strata than the ones calculated for the entire comet nucleus (the bilobed comet) (fig. 2). The inherent implications of such evidences are: i) cometesimals can merge via low velocity impacts in the porto-planetary disk, ii) comets can not longer be considered as chaotic aggregates as generally

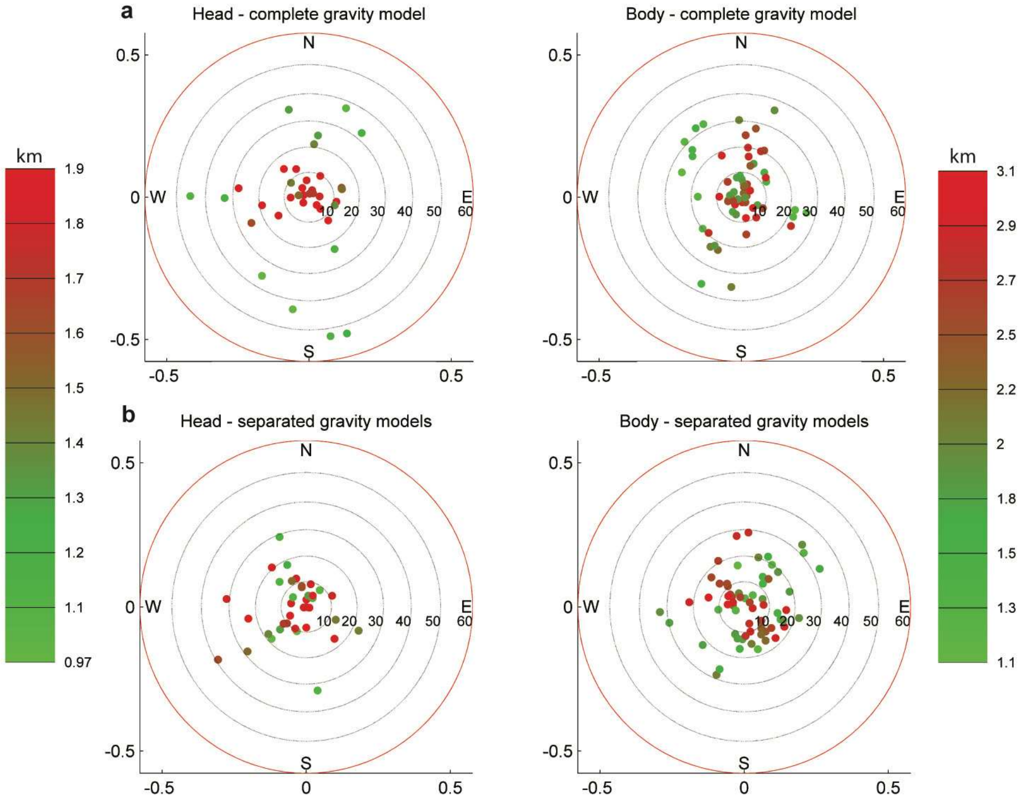

Fig. 2. Stereographic projections of strata plane-normal vectors (i.e. strata poles) of the minor lobe called "head" (left) and the major lobe called "main body" (right). The stereo-plots are in the reference frame defined by the local gravity vector such that each circle defines steps of 10° of angular deviation between the strata poles and the local gravity vector calculated for the whole nucleus (a) and for the two separated objects (b). Color scale-bars are referred to the head (left) and main body (right) and indicate the distance of the plane centers with respect to the point of intersection between the two reconstructed lobes.

believed so far and iii) 67P/CG must have escaped any catastrophic collision during the entire Solar System evolution.

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