LAYERING ON COMET 67P/CHURYUMOV-GERASIMENKO: INSIGHTS FROM THREE-DIMENSIONAL MODELING.

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Introduction: ESA's Rosetta spacecraft offered the unique opportunity to observe comet 67P/Churyumov-Gerasimenko with unprecedented resolution thanks to the onboard camera system OSIRIS [1]. This two-cameras system allowed the identification of a surprisingly complex surface morphology, comprising a striking set of geological features, as extended fractures, circular pits, scattered blocks, gravitational deposits connected with collapses and sets of morphological terraces, stacked in staircase patterns [2].

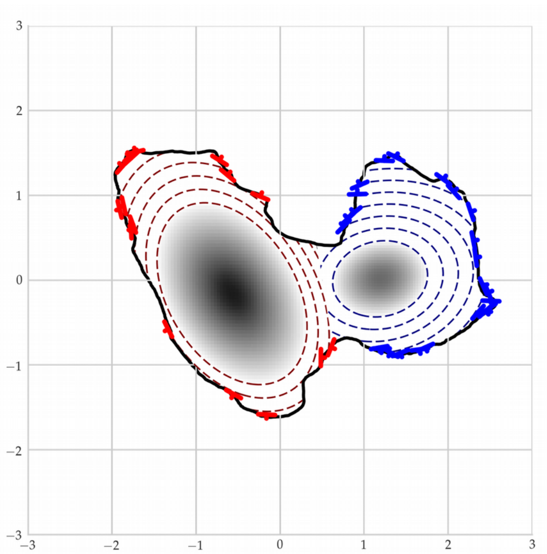

Figure 1: Cross section of 67P showing the modeled orientation of the layers in the subsurface. The two lobes of comet 67P are independently layered in onion-like wrappings of ordered layers. Blue and red markers represent the orientation of terraces near the section plane. Grid in km on the section plane.

Comet 67P has a peculiar bilobate shape which is thought to be the result of a non-destructive collisional event that joined two independent objects, forming the two lobes. The presence of ordered terraces, together with linear traces visible on cliffs consistently aligned with the nearby terraces, suggested the presence of an inner layering [3], independently wrapping each lobe.

We provide a detailed summary of the present-day knowledge about the geometry and the general aspect of the layering on 67P by using OSIRIS images and the derived three-dimensional shape model [4].

Methods: By using the orientation of the terraces as a proxy for the layers, it was shown that the overall structure of the layers can be reasonably well approximated by mean of ellipsoidal shapes [5], implying two unique and overall-ordered organization for the layers, one for each lobe, resembling layers of an onion, as represented in Figure 1.

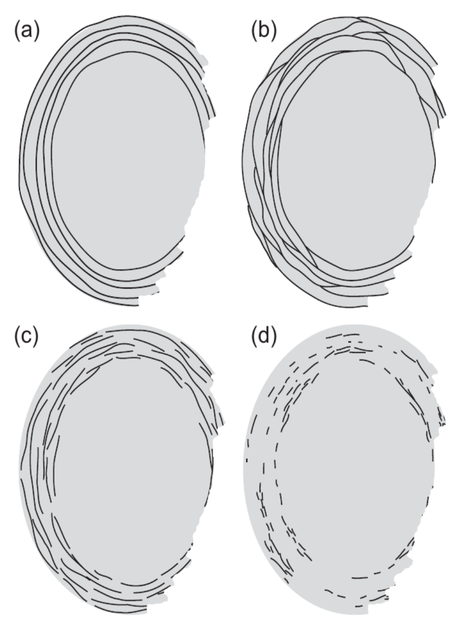

Figure 2: Whether the discontinuity surfaces defining the layers are laterally continuous or not is still under investigation. Several different configurations could lead to similar terraced morphologies.

Each layer is an extended tabular volume of cometary material, which is delimited at the top and at the bottom by two curved discontinuity surfaces. These surfaces might be either laterally persistent (Figure 2a) or assume any configuration as the ones of Figure 2b, 2c and 2d.

Results: All the observations of the layering are based on surface data, which by themselves constitute a two-dimensional and incomplete set of observations. For this reason it is impossible to follow a single layer all around the cometary body, and discerning between any of the presented configurations of discontinuities, although the ones represented in Figure 2b and 2c are the most likely, due to the large extension of observed terraces.

These discontinuities can be observed in high resolution images, where, using the 3D model proposed in [5] as a stratigraphic reference frame, we determined an average layers thickness by counting the number of visible layer-forming discontinuities in respect to the stratigraphy they represent as depicted in Figure 3. We determined an average layers thickness of approximately 20 meters in this case but in other regions we found layers with thickness as small as 2 meters.

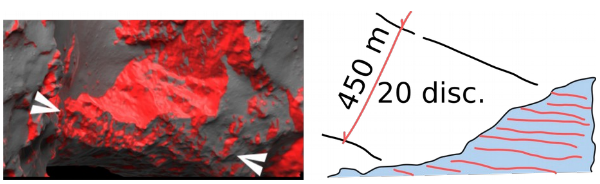

Figure 3: By subdividing the thickness of the layering by the number of terraces we obtained an average layer thickness of 20 meters.

The same three-dimensional model can be also used to identify regions that expose deeper layers with respect to shallower ones, hence highlighting an overall dichotomy between the Northern and the Southern hemispheres of comet 67P (see Figure 1): indeed the overall geometry of the ellipsoidal layering exposes deeper terrains in the Southern hemisphere, while it still preserves some shallower terrains in the form of *mesas* in the Northern one.

By extending the present-day morphologies using the three-dimensional model we were able to quantify the amount of missing *cometary* material, suggesting an overall loss of 60-70 % of the reconstructed initial volume, estimated on the basis of the shallower layers in the Northern hemisphere.

The lost volumes appear to be concentrated in the neck region and at the opposite sides of the lobes, at the Imhotep and Hatmehit depressions, in a symmetric fashion around the axis connecting the two lobes.

Furthermore a large portion of volume pertinent to the smaller lobe is predicted by the three-dimensional model to extend and overlap with the layers of the other lobe, suggesting that this specific volume of material was lost before (or contextually) the junction of the two lobes, and not as a consequence of sublimation processes occurring after the junction.

From the refinement of the ellipsoid-based three-dimensional model [5] using GoCAD software we were able to further constraint the layers geometry, showing that the layers appear to be slightly deformed near the neck region.

Evidences suggesting missing volumes and deformation of layers appear to be linked to the non destructive collisional event which brought the two lobes together, providing insights on the mechanisms and events that brought to the observed configuration of the comet.

References:

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Acknowledgements: OSIRIS was built by a consortium of the Max-Planck-Institut fur Sonnensystem-forschung, in Gottingen, Germany, CISAS-University of Padova, Italy, the Laboratoire d'Astrophysique de Marseille, France, the Instituto de Astrofisica de Andalucia, CSIC, Granada, Spain, the Research and Scientific Support Department of the European Space Agency, Noordwijk, The Netherlands, the Instituto Nacional de Tecnica Aeroespacial, Madrid, Spain, the Universidad Politechnica de Madrid, Spain, the Department of Physics and Astronomy of Uppsala University, Sweden, and the Institut fur Datentechnik und Kommunikationsnetze der Technischen Universitat Braunschweig, Germany. The support of the national funding agencies of Germany (DLR), Italy (ASI), France (CNES), Spain (MEC), Sweden (SNSB), and the ESA Technical Directorate is gratefully acknowledged. We thank the ESA teams at ESAC, ESOC and ESTEC for their work in support of the Rosetta mission.