EPSC Abstracts
Vol. 12, EPSC2018-664-1, 2018
European Planetary Science Congress 2018
© Author(s) 2018

Layering-Related Linear Features on Comet 67P

Birko-Katarina Ruzicka (1,2), Hermann Boehnhardt (1), Luca Penasa (3) and Andreas Pack (2)
(1) Max Planck Institute for Solar System Research, Planets and Comets, Goettingen, Germany (ruzicka@mps.mpg.de)
(2) Georg-August-Universität Göttingen, Geowissenschaftliches Zentrum, Goldschmidtstraße 1, 37073 Göttingen, Germany
(3) Center of Studies and Activities for Space, 'G. Colombo', University of Padova, Via Venezia 15, 35131 Padova, Italy

Abstract

We studied the three-dimensional orientation of layerings in the nucleus of comet 67P/Churyumov-Gerasimenko ('67P'). Using high-resolution 2D images from the OSIRIS Camera system onboard the Rosetta spacecraft in combination with a 3D shape model of the nucleus, we mapped presumably layering-related linear features on the comet's surface, then applied methods of structural geology to predict their subsurface orientation. Our results independently confirm the internal structure proposed by preceding works [1,2] of a nucleus whose two lobes are independently concentrically layered to a depth of at least several hundred meters below the nucleus surface.

1. Introduction

Photographic images of the nucleus surface of 67P suggest that the comet may have a layered internal structure, which would hold clues to the comet's formation and evolution in the early Solar System.

Previous works concluded that the two lobes of the nucleus of 67P are individually wrapped in 'onion-like' stratification that formed through accretion before the bodies merged in a gentle collision in the early Solar System [1]. The layerings and internal structure were later modelled by fitting ellipsoidal shells to "terraces" on both lobes [2]. Both of these approaches are based on planar terrace features, whereas our method relies exclusively on linear surface features.

2. Methods

We identified and mapped linear layering structures on the nucleus surface, determined their normal vectors, and analysed their orientation relative to each other.

We focused our study on morphological edges between terraces and the steep cliff faces below them ("edges"), as well as linear discontinuities visible on hill slopes and cliff faces ("strata heads").

We aligned high-resolution 2D images from the OSIRIS Narrow Angle Camera on the lower-resolution SHAP5 shape model on the nucleus. We

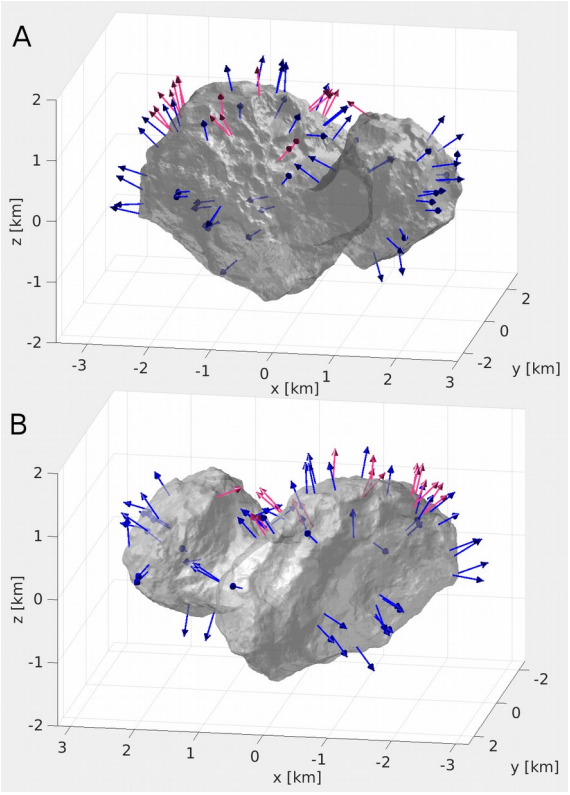

Figure 1: Shape model of comet 67P showing the normal vectors of the best-fitting planes to the mapped terrain edges (blue arrows) and strata heads (pink arrows). Coordinates are in the Cheops reference frame. A: 'Front' view towards positive y-values; B: 'Back' view rotated around the z-axis by 180°.

then mapped the linear features on these aligned images, fitted planes through all features with sufficient curvature, and analysed the orientation of the plane-normals.

3. Results

We mapped 74 linear features on a total of 30 aligned OSIRIS images. 56 of the features are classified as terrace edges and 18 as strata heads. The plane-normals fitted to these features are illustrated in Figure 1.

4. Interpretation and Conclusions

Our proposed layering-normals are close to perpendicular to the nucleus surface, independent of their location on the nucleus or their distance to the gravitational centre of the respective lobe (Figure 1). In terms of structural geology, this means that the layerings are in a centroclinal configuration, i.e. they are concentric. The majority of layering-normals are furthermore parallel with, or at small angles (< 20°) to the normals of a set of concentric ellipsoids inscribed to the lobes (see [2]).

Concentric layerings have previously been proposed through the analysis of planar terraces [1,2]. The terrace surfaces on 67P are, however, visibly and extensively covered in deposits of fine-grained material and larger debris [3], such that the orientation of these surfaces might not be equal to the orientation of the underlying layerings. This limitation is acknowledged [2] and the authors estimate that this might introduce errors of up to 20° on the estimated orientation of the terraces. By focusing on the edges of terraces and outcropping strata, we avoided the effect of sedimentary deposition upon our measurements. In turn, our terrace edges are somewhat influenced by erosional processes.

In conclusion, we found that normals, fitted to layering planes at various distances from the respective lobes' centres across most of the nucleus surface of comet 67P, are approximately perpendicular to the nucleus surface. Furthermore, fitting our measurements with concentric ellipsoidal shells yields a result similar to [2] and supports that the comet is enveloped in numerous concentric layerings to a depth of at least several hundred metres. Our results, especially the orientations of the layering normals adjacent to the comet's neck, add to the large body of evidence that 67P consists of two independently formed bodies that were joined together in a gentle collision (e.g. [4,5,6]).

Acknowledgements

This work is part of a PhD thesis conducted at the International Max Planck Research School (IMPRS). It greatly benefited from collaboration with Matteo Massironi and his research group at the University of Padua. The OSIRIS team provided the OSIRIS SHAP5 data set. The mapping software was provided by Magellium in collaboration with the Centre National D'etudes Spatiales (CNES).

References

[1] Massironi, M. et al.: Two independent and primitive envelopes of the bilobate nucleus of comet 67P, Nature, Vol. 526, pp. 402-405, 2015.

[2] Penasa, L. et al.: A three dimensional modelling of the layered structure of comet 67P / Churyumov-Gerasimenko, Monthly Notices of the Royal Astronomical Society, V. 14, pp. 1-14, 2017.

[3] Groussin, O. et al.: Gravitational slopes, geomorphology, and material strengths of the nucleus of comet 67P/Churyumov-Gerasimenko from OSIRIS observations, Astronomy and Astrophysics, V. 583, A32, 2015.

[4] Davidsson, B.J.R. et al.: The primordial nucleus of comet 67P/Churyumov-Gerasimenko, Astronomy & Astrophysics, V. 592, A63, 2016.

[5] Jutzi, M., and Benz, W.: Formation of bi-lobed shapes by sub-catastrophic collisions, Astronomy & Astrophysics, V. 597, A62, 2017.

[6] Jutzi, M. et al.: How primordial is the structure of comet 67P?, Astronomy & Astrophysics, V. 597, A61, 2017.