Evolution of the subsurface of 67P/Churyumov-Gerasimenko's Abydos Site

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CHARACTERIZATION OF THE SUBSURFACE OF 67P/CHURYUMOV-GERASIMENKO’S ABDYOS SITE


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INTRODUCTION

On November 12, 2014, Rosetta’s descent module Philae landed on the Abydos site of comet 67P/Churyumov-Gerasimenko (67P). Among the instruments onboard Philae, the Ptolemy mass spectrometer performed the analysis of several samples collected from the surface and atmosphere of the comet. Here we investigate the structure of the subsurface of the Abydos site. To do so, we employ a one dimensional cometary nucleus model [1] with an updated set of thermodynamic parameters relevant for 67P. The comparison of the production rates derived from our model with those measured by Ptolemy allows us to place constraints on the structure of the subsurface of Philae’s landing site.

MODEL AND PARAMETERS

We consider a mixture of crystalline ices (H₂O, CO and CO₂) and dust, with parameters updated from the recent Rosetta measurements (see TABLE 1). Based on the ROSINA observations [2], we assume CO/H₂O = 0.13±0.07 and CO₂/H₂O = 0.08±0.05 as a starting composition in the matrix. Two key parameters, the dust/ice mass ratio and the porosity, initially set at 4.5% [3] and 65±2% [4] respectively, are allowed to vary in the model (see FIGURE 1).

TABLE 1. List of physical and orbital parameters of 67P’s nucleus used in this work.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi major axis</td>
<td>3.463 UA</td>
</tr>
<tr>
<td>Eccentricity</td>
<td>0.641</td>
</tr>
<tr>
<td>Initial radius of the nucleus</td>
<td>2.43 km</td>
</tr>
<tr>
<td>Rotational period of the comet</td>
<td>12.4 h</td>
</tr>
</tbody>
</table>

FIGURE 1. Nucleus porosity as a function of the dust/ice mass ratio, as to match a density of 510 kg/m³ in the nucleus.

RESULTS AND DISCUSSION

We find that the best match of the Ptolemy measurements at a close time period of 67P’s orbital evolution corresponds to CO/H₂O and CO₂/H₂O set at minimum and maximum respectively, giving CO/CO₂ = 0.46, and with a dust/ice ratio of 6 (porosity of 78%).

Assuming that the 67P’s nucleus is a mixture of crystalline ices and dust, we find that high dust/ice ratios are needed at the subsurface of Abydos to match the CO/CO₂ value measured by Ptolemy at Philae’s landing epoch (November 12, 2014). Higher dust/ice ratios than those found in the comet literature are desirable if one wants to improve the time matching of the data. Our preliminary results suggest that 67P is heterogeneous.

REFERENCES

[3] Fulle et al. 2015. LPI 46, 2420F.