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Electrical properties of the first meters of 67P/Churyumov-Gerasimenko's nucleus as constrained by PP-SESAME/Philae/Rosetta

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On November 12, 2014, the Philae module landed on the surface of the nucleus of 67P/Churyumov-Gerasimenko. Among the instruments on-board Philae, the Permittivity Probe experiment (hereafter PP-SESAME), which is part of the SESAME (Surface Electric Sounding and Acoustic Monitoring Experiment) package, operated both during descent and on the surface. The primary scientific objective of this experiment is to measure the low frequency (10 Hz-10 kHz) complex permittivity i.e. the dielectric constant and electrical conductivity, of the first meters of the cometary nucleus. Doing so, it aims at providing insights into the composition of the mantle and in particular into the water content and porosity of the first meters below the surface.
In this paper, we will present the data acquired at the final landing site of Philae known as Abydos and the approach we have developed to analyze them. We emphasize that, because the configuration of operation of PP-SESAME was far from nominal, we had to adapt our analysis method in order to account for all available constraints on Philae attitude and environment at Abydos. We also had to do without the in-flight calibration performed during the descent phase but unfortunately perturbed by the concurrent operations of the bistatic radar CONSERT.
We find that the first meters of the nucleus at Abydos are made of a likely pure dielectric material (i.e. with a null conductivity) which dielectric constant is larger than 2.3. This lower bound of the dielectric constant is significantly higher than the value of 1.27 inferred from the propagation time of the CONSERT signals that propagated through the smaller lobe of the comet in the vicinity of Abydos reaching depths of a few hundreds of meters. Thus, while PP-SESAME measurements put no constraint on the dust-to-ice ratio, they strongly suggest that the first meters of the nucleus are significantly more compacted (with a porosity below 50%) than its interior as sensed by CONSERT (found to have a porosity in of 75 to 85%, consistent with the low density of the nucleus).
In light of other Philae and Rosetta observations, we will discuss the implications of these findings in terms of formation and evolution of cometary mantles.