



The Philae Lander reveals the presence of low strength primitive ice inside cometary boulders

Laurence O'Rourke¹ and the Philae on Skull-top Crevice team*

¹European Space Agency, SRE-OD, Villanueva del Pardillo, Spain (lorourke@esa.int)

*A full list of authors appears at the end of the abstract

On the 12 November 2014, the Philae lander descended towards comet 67P/Churyumov–Gerasimenko, bounced twice off the surface, finally arriving under an overhanging cliff in the Abydos region. In this study (published in Nature on 28th Oct 2020), we present the results of our investigation of a previously undiscovered site of the second touchdown, where Philae spent almost two minutes of its cross-comet journey, producing four distinct surface contacts on two adjoining cometary boulders. It exposed primitive water ice —that is, water ice from the time of the comet's formation 4.5 billion years ago — in their interiors while travelling through a crevice between the boulders. Our multi-instrument observations made 19 months later found that this water ice, mixed with ubiquitous dark organic-rich material, has a local dust/ice mass ratio of $2.3 \pm 0.2 / -0.16 : 1$, matching values previously observed in freshly exposed water ice from outbursts and water ice in shadow. At the end of the crevice, Philae fell forward and left a 0.25-metre-deep impression in the boulder ice, providing in situ measurements confirming that primitive ice has a very low compressive strength (less than 12 pascals, softer than freshly fallen light snow) and allowing a key estimation to be made of the porosity (75 ± 7 per cent) of the boulders' icy interiors. Our results provide constraints for cometary landers that seek to access a volatile-rich ice sample.

Philae on Skull-top Crevice team: Philip Heinisch, Jürgen Blum, Sonia Fornasier, Gianrico Filacchione, Hong Van Hoang, Mauro Ciarniello, Andrea Raponi, Bastian Gundlach, Rafael Andrés Blasco, Björn Grieger, Karl-Heinz Glassmeier, Michael Küppers, Alessandra Rotundi, Olivier Groussin, Dominique Bockelée-Morvan, Hans-Ulrich Auster, Nilda Oklay, Gerhard Paar, Maria del Pilar Caballo Perucha, Gabor Kovacs, Laurent Jorda, Jean-Baptiste Vincent, Fabrizio Capaccioni, Nicolas Biver, Joel Wm. Parker, Cecilia Tubiana & Holger Sierks