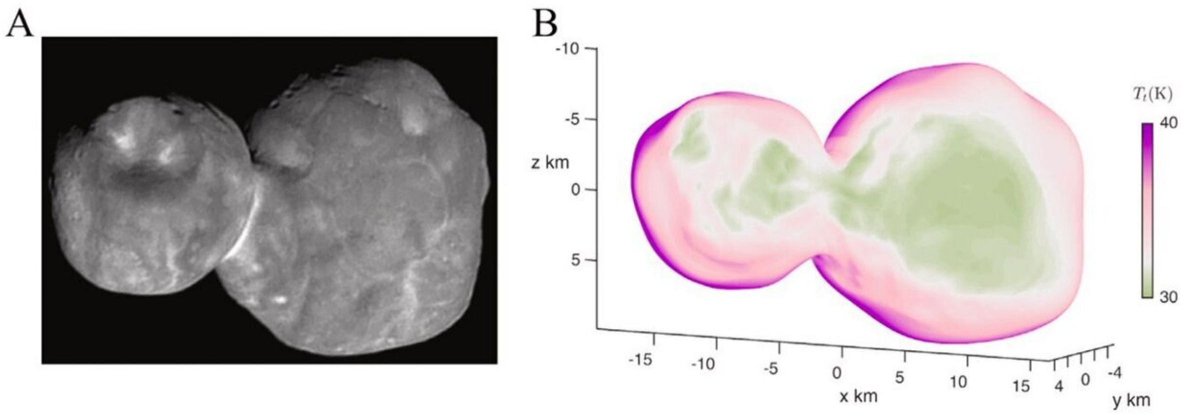
Study reveals ancient ice may still exist in distant space objects

March 14 2024



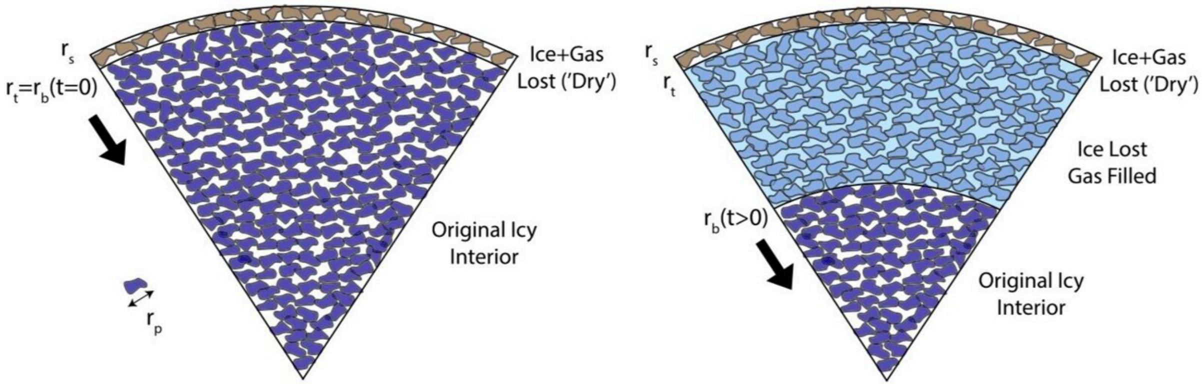
Left image was captured by the Multicolor Visible Imaging Camera (MVIC), a part of the ralph instrument aboard New Horizons. Taken on January 1, 2019, just 7 minutes before its closest approach, the spacecraft was only about 6700 km from the surface. Credit for this remarkable capture goes to NASA, Johns Hopkins University Applied Physics Laboratory, and Southwest Research Institute. Right image shows the orbitally averaged temperature at the seasonal skin depth of Arrokoth, calculated based on Umurhan et al.'s 2022 method. The scale is in kilometers, and the view orientation is similar to image on left, looking down towards the south pole. Credit: NASA, Johns Hopkins University Applied Physics Laboratory, and Southwest Research Institute

A paper recently published in *Icarus* presents findings about the Kuiper Belt Object 486958 Arrokoth, shedding new light on the preservation of volatile substances like carbon monoxide (CO) in such distant celestial bodies.

Co-authored by Dr. Samuel Birch at Brown University and SETI Institute senior research scientist Dr. Orkan Umurhan, the paper "Retention of CO Ice and Gas Within 486958 Arrokoth" uses Arrokoth as a case study to propose that many Kuiper Belt Objects (KBOs)—remnants from the dawn of our solar system—could still retain their original volatile ices, challenging previous notions about the evolutionary path of these ancient entities.

Previous KBO evolution models have needed help predicting the fate of volatiles in these cold, distant objects. Many relied on cumbersome simulations or flawed assumptions, underestimating how long these substances could last. The new research offers a simpler yet effective approach, likening the process to how gas escapes through porous rock. It suggests that KBOs like Arrokoth can maintain their volatile ices for billions of years, forming a kind of subsurface atmosphere that slows further ice loss.

"I want to emphasize that the key thing is that we corrected a deep error in the physical model people had been assuming for decades for these very cold and old objects," said Umurhan. "This study could be the initial mover for re-evaluating the comet interior evolution and activity theory."



Our model features a porous rubble pile, made up of a mix of CO and refractory amorphous H_2O ice, with specific pore radii □□□□. The top layer, depicted in brown, undergoes thermal processing in just one orbit, resulting in the loss of CO (both ice and gas) in this layer. Below the sublimation front □□□□, shown in dark blue, the original CO ice volume remains intact. Over time, as the sublimation front progresses downward (to the right in the model), CO ice embedded in the amorphous H_2O ice matrix begins to sublimate. The gas produced, indicated in light blue, then fills the pores and moves upward, away from the sublimation front. Credit: SETI Institute

This study challenges existing predictions and opens up new avenues for understanding the nature of comets and their origins. The presence of such volatile ices in KBOs supports a fascinating narrative of these objects as "ice bombs," which activate and display cometary behavior upon altering their orbit closer to the sun.

This hypothesis could help explain phenomena like the intense outburst activity of comet 29P/Schwassmann–Wachmann, potentially changing the understanding of comets.

As co-investigators on the upcoming CAESAR mission proposal, the researchers are taking a fresh approach to understanding the evolution and activity of cometary bodies. This study has implications for future explorations and is a reminder of the enduring mysteries of our solar system, waiting to be uncovered.

More information: Samuel P.D. Birch et al, Retention of CO ice and gas within 486958 Arrokoth, *Icarus* (2024). DOI: 10.1016/j.icarus.2024.116027

Provided by SETI Institute