PAPER CHECK · URANUS'S MOON ARIEL

Ariel's ocean is written in its cracks, not yet seen

A study of the fractured surface of Uranus's moon Ariel concludes it once needed a subsurface ocean, possibly more than 170 km deep [1 ¶1]. The ocean is a reasonable inference from a model, not a detection. The 170 km figure is the model's thin-ice solution, and it needs an orbit far more stretched than Ariel's today.

By Fact-Checked Science · Published October 13, 2026

OUR ANALYSIS marks our own reasoning and calculations, and the verdicts are our assessment. We couldn't read the paper itself [2]; what it found comes here from the Planetary Science Institute's release, the team's 2024 conference abstract and the coverage.

A reasonable inference, not a measurement

OUR ASSESSMENT

~40%
of Ariel's surface was imaged, all of it in the south, in the one close look: Voyager 2 in 1986 [3 ¶7][1 ¶9][4].

≥ 0.04
The orbital eccentricity the model needs, 30–40 times today's. A 2026 study finds that one candidate cause, a 2:1 resonance with the moon Umbriel, reaches only about 0.02 [1 ¶6][5].

~85%
Our estimate of how much of the thickness of Ariel's water layer a 170 km ocean would take up if its rock is near 3 g/cm³, leaving about 27 km of ice on top.

THE CLAIMS ABOUT ARIEL'S OCEAN

TRUE

Ariel's cracks point to a past ocean

The release's headline [1]

In the team's stress models, the fractures form only with an ocean beneath the ice: thin ice over a very big ocean, or a smaller ocean with a more stretched orbit [1 ¶7]. It is an inference from a model, from images of part of the surface and from an orbit about 0.04 eccentric or more, not a detection. See section 2.

UNCONFIRMED

It may have been more than 170 km deep

The release, and headlines such as ScienceDaily's [1 ¶1][6]

This is the model's thin-ice solution, which needs the least stretched orbit, at least 0.04. Unhedged headlines, such as "Ariel Had A 170km Deep Sub-Surface Water Ocean," overstate it [7]. See section 1.

UNCONFIRMED

Its orbit was once about 40 times more stretched

The release [1 ¶6]

This is what the model needs to crack the ice, not an observed value. A 2026 study finds that one candidate cause, a 2:1 resonance with Umbriel, raises Ariel's eccentricity only to about 0.02 [5]. See section 3.

UNCONFIRMED

An ocean lurks beneath Ariel's ice today

The release's opening line, as what "growing evidence suggests" [1 ¶1]

The study is about the past. Models suggest any ocean left today would likely be a residual layer under 30 km thick, and only measurements by a spacecraft at Uranus, such as magnetometry, could find it [8 Abstract][9 Abstract]. See section 5.

1 · WHAT 170 KM WOULD MEAN

A 170 km ocean would fill most of Ariel's water layer

The release says new research in *Icarus* found that Ariel's ocean "may have once been over 100 miles (170 kilometers) deep", against the Pacific's average of 4 kilometres [1 ¶1][2][10]. Drawn to scale, that is most of the moon's outer shell of water and ice.

Half of Ariel, to scale

OUR ANALYSIS

- **Ice shell, about 27 km** — What is left above a 170 km ocean
- **Ocean, 170 km deep** — The headline case [1 ¶1]
- **Rocky core, about 382 km in radius** — Our assumption, from Ariel's density
- **The two bars on the right** — The Pacific's 4 km average depth, a sliver, beside 170 km, at the same scale

Ariel's radius is 578.9 km and its mean density 1.539 g/cm³ [11]. The interior is our two-layer estimate, not the paper's: rock near 3 g/cm³ under water and ice gives a water layer about 197 km thick, about 150–240 km for other plausible densities. The team's 2024 conference abstract for the same study suggested "a thin (≤ 30 km) ice shell" [12].

POSSIBLE PAST OCEAN
170 km
Over 40 times the Pacific's average depth of 4 km [1 ¶1].

PAST ECCENTRICITY NEEDED
≥ 0.04
About 30–40 times today's and 4 times Europa's [1 ¶6][13][14].

THE ONLY CLOSE LOOK
1986
One Voyager 2 flyby, the first and so far the only visit to Uranus [4].

2 · READING AN OCEAN FROM CRACKS

How the study reads an ocean from Ariel's cracks

Ariel has old craters beside young, smooth terrain that may come from cryovolcanism, and fractures, ridges and grabens "at scales larger than almost anywhere else in the Solar System" [1 ¶3]. The team asked what interior and orbit could have cracked it this way [1 ¶4].

STEP 1
Map the big structures
Fractures, ridges and grabens (blocks of crust that have dropped below their surroundings) [1 ¶3][1 ¶5].

STEP 2
Model the tidal stresses
On an eccentric orbit, the tidal bulge Uranus raises on Ariel grows and shrinks, and rocks back and forth, as the moon's distance from the planet changes [1 ¶5].

STEP 3
Match stress to structure
Find the orbit and interior whose stresses could have cracked the surface this way. The answer requires an ocean [1 ¶7][12].

Two ways to crack the ice

Thin ice, very deep ocean — **Thicker ice, shallower ocean**

"In order to create those fractures, you have to have either a really thin ice on a really big ocean, or a higher eccentricity and a smaller ocean," said co-author Alex Patthoff. "But either way, we need an ocean to be able to create the fractures that we are seeing on Ariel's surface" [1 ¶7].

Schematic, with the same core and water layer; the release gives no thicknesses for the thicker-ice case.

OUR ANALYSIS

170 km is the thin-ice solution, not an outlier

The deep ocean goes with the least eccentric orbit, at least 0.04, and a shallower ocean needs an even more stretched one [1 ¶7][5]. The team's 2024 abstract presented the thin-ice case as its result: "Our modeling suggests a thin (≤ 30 km) ice shell during a period when Ariel's eccentricity was ~0.045" [12]. It framed Miranda the same way, with a crust of 30 km or less over an ocean of 100 km or more [15 Abstract].

With Ariel's density and rock near 3 g/cm³, a 170 km ocean would take up about 85% of the water layer's thickness, leaving roughly 25–35 km of ice, in line with that abstract.

3 · A SMALL NUMBER WITH A BIG EFFECT

An orbit that still looks round could have cracked the ice

"While 0.04 may not sound dramatic, eccentricity can strengthen the effects of tidal stresses," the release says, and "to the eye, the orbit will still resemble a circle" [1 ¶6].

An eccentricity of 0.04, to scale

Uranus (the large dot) sits 4% of the way from the centre; the orbit's short axis is 0.08% shorter than its long one.

How stretched each orbit is

Eccentricity: 0 is a circle. Today's Ariel is 0.001 in JPL's table and 0.0012 in NASA's fact sheet.

OUR ANALYSIS

Tides weaken with the cube of the distance, so at an eccentricity of 0.04 the tidal stretch would swing by roughly ±12% every orbit: 13% stronger than at the average distance at the closest point, 11% weaker at the farthest. That flexes the ice every 2.5 days, the length of Ariel's orbit [13]. Today the swing is less than ±0.5%.

What stretched the orbit?

The team's 2024 abstract pointed to a past resonance with the moon Umbriel, as earlier dynamical studies had proposed, without saying which one [12]. A 2026 study looked at the 2:1 resonance with Umbriel, which older work ruled out but which, it argues, Ariel almost certainly crossed if Uranus's tides are as strong as recent estimates suggest. It found that this resonance lifts Ariel's eccentricity only to about 0.02, and called reaching 0.04 "very difficult" [5]. How Ariel got to 0.04 is still a hypothesis.

4 · LESS THAN HALF A MOON, SEEN ONCE

Everything rests on part of one hemisphere, photographed in 1986

Imaged by Voyager 2, about 40% of the surface
Never imaged

Schematic: a southern cap covering 40% of a sphere, seen side-on.

Voyager 2 imaged only about 40% of Ariel's surface, at a resolution relatively low compared with missions to Europa or Enceladus [3 ¶7][17]. The northern hemispheres of the Uranian moons were largely unobservable during the flyby and were not imaged [18 Abstract].

The team says its results predict where fractures and ridges should appear in the unseen north, a test a future spacecraft could run [1 ¶9].

5 · WHAT WOULD SETTLE IT

Confirming an ocean needs a spacecraft back at Uranus

The study argues an ocean was needed to explain the cracks. Testing that takes new measurements, and some of them could only find an ocean that survives today.

What would settle it

01
Magnetometry. A salty ocean would answer Uranus's changing magnetic field with an induced field of its own. Lead author Caleb Strom says magnetometry could provide definitive evidence of an ocean that still exists [3 ¶10], and modelling suggests even a single close flyby could detect one [9 Abstract].

02
Gravity and shape. How much Ariel deforms under Uranus's pull would help show whether a liquid layer lies beneath the ice today; models of the moons' interiors predict this tidal response [8 Abstract].

03
The northern hemisphere. Imaging it, ideally from an orbiter arriving near equinox, would test the predicted fracture pattern and so the account of the past ocean [3 ¶9][1 ¶9].

Models suggest that any ocean left today would be a residual layer less than 30 km thick in Ariel, and an ocean rich in ammonia might conduct too poorly to detect [8 Abstract].

6 · OUR ASSESSMENT

A solid addition, read with its assumptions

This section is our assessment, from the release, the team's abstract and the coverage; we could not read the paper.

OUR ANALYSIS

Inferred, not observed

The release says "evidence of a past, deep ocean"; the paper's title says "constraining ocean and ice shell thickness" [1][2]. The ocean is what a model needs to explain the cracks.

OUR ANALYSIS

The orbit is the weak link

Every version of the model needs an eccentricity of at least 0.04, and how Ariel got there is unsettled: a 2026 study finds the 2:1 resonance with Umbriel reaches only about 0.02 [5]. If Ariel never got there, the stresses that crack the ice need another source.

OUR ANALYSIS

Past or present?

The release opens by saying "growing evidence suggests" an ocean "lurks beneath the icy surface" today [1 ¶1], but this study is about the past: the team's 2024 abstract put the thin shell "in the geologically recent past" [12], and the researchers aren't sure exactly how long ago the deep ocean might have existed [1 ¶10].

OUR ANALYSIS

170 km means most of the water was liquid

By our estimate, Ariel's whole water-ice layer is about 150–240 km thick, about 200 km if its rock is near 3 g/cm³. In that case a 170 km ocean would be most of it, leaving roughly 25–35 km of ice; if the rock is lighter than about 2.7 g/cm³, there is little or no room for it. A big claim, but the one the team's model points to, not an extreme reading of it.

OUR ANALYSIS

Thin data

Everything rests on 1986 images of about 40% of the surface, all in the south, at Voyager-era resolution, which the team acknowledges [1 ¶9][3 ¶7].

OUR ANALYSIS

Old news, recirculated

The release came out on September 29, 2025. ScienceDaily ran a rewritten version, with new subheads but the same quotations, on September 24, 2026, under a headline ending "Uranus' moon Ariel may have hidden a 100-mile-deep ocean," with the same artist's impression [6][1 ¶0].

OUR ANALYSIS

Bottom line: a solid addition to the case that Uranus's major moons were once ocean worlds, alongside the same team's similar result for Miranda [1 ¶8][15 Abstract]. Read "100-mile-deep ocean" as the thin-ice solution of a model that needs Ariel's orbit to have been at least 30 times more stretched than today's, not as a measurement.

Sources

Bracketed numbers refer to this list; ¶ gives a paragraph of a web page, counted as its entry explains, and Abstract names the part of a work we used. Links checked October 13, 2026.

1. Kelley, M. M. (2025). Evidence of a past, deep ocean on Uranian moon, Ariel. Planetary Science Institute, September 29, 2025. ¶ counts the paragraphs of its text; ¶0 is the photo caption.
2. Strom, C., Nordheim, T. A., Patthoff, D. A., and Fieber-Beyer, S. K. (2026). Constraining ocean and ice shell thickness on Ariel from surface geologic structures and stress mapping. *Icarus* 444, 116822. We could not read this paper or its abstract.
3. SETI Institute (2025). The Hidden Ocean of Ariel: Tidal Forces and the Case for a Watery Past. November 7, 2025. A write-up of a SETI Live conversation with Caleb Strom and Alex Patthoff. ¶ counts the paragraphs of its text after the photo caption, not counting the "At a Glance" list.
4. NASA Science. Uranus: Exploration. Accessed October 13, 2026.
5. Lari, G., and Rossi, M. (2026). Tidal heating of the Uranian moons during the 2:1 resonance between Ariel and Umbriel. Europlanet Science Congress 2026, EPSC2026-164. Conference abstract.
6. "We just need to go back" – Uranus' moon Ariel may have hidden a 100-mile-deep ocean. *ScienceDaily*, September 24, 2026. Source: Planetary Science Institute.
7. Tomaswick, A. (2025). Ariel Had A 170km Deep Sub-Surface Water Ocean. *Universe Today*, October 2, 2025. CC BY 4.0.
8. Castillo-Rogez, J., Weiss, B., Beddingfield, C., Biersteker, J., Cartwright, R., Goode, A., Melwani Daswani, M., and Neveu, M. (2023). Compositions and Interior Structures of the Large Moons of Uranus and Implications for Future Spacecraft Observations. *Journal of Geophysical Research: Planets* 128(1), e2022JE007432. CC BY-NC 4.0.
9. Cochrane, C. J., Vance, S. D., Nordheim, T. A., Styczinski, M. J., Masters, A., and Regoli, L. H. (2021). In Search of Subsurface Oceans Within the Uranian Moons. *Journal of Geophysical Research: Planets* 126(12), e2021JE006956. CC BY-NC 4.0.
10. NOAA National Centers for Environmental Information. World Ocean Volumes (ETOPO1). Accessed October 13, 2026.
11. JPL Solar System Dynamics. Planetary Satellite Physical Parameters. Accessed October 13, 2026.
12. Strom, C., Nordheim, T., Patthoff, A., and Fieber-Beyer, S. K. (2024). Constraining ocean and ice shell thickness on Ariel using geologic structure mapping and stress modeling. GSA Connects 2024, Anaheim, paper 91-1. *Geological Society of America Abstracts with Programs* 56(5). The team's conference abstract for the same study.
13. JPL Solar System Dynamics. Planetary Satellite Mean Elements. Accessed October 13, 2026.
14. Williams, D. R. Uranian Satellite Fact Sheet. NASA Space Science Data Coordinated Archive, updated March 11, 2023.
15. Strom, C., Nordheim, T. A., Patthoff, D. A., and Fieber-Beyer, S. K. (2024). Constraining Ocean and Ice Shell Thickness on Miranda from Surface Geological Structures and Stress Modeling. *The Planetary Science Journal* 5(10), 226. CC BY 4.0.
16. JPL Solar System Dynamics. Approximate Positions of the Planets. Accessed October 13, 2026.
17. Tonoian, S., Lucchetti, A., Massironi, M., Penasa, L., Beddingfield, C., Pajola, M., Rossi, C., and Pozzobon, R. (2026). Geometry of chasmata on Ariel's surface and its implications. Europlanet Science Congress 2026, EPSC2026-490. Conference abstract.
18. Cartwright, R. J., Beddingfield, C. B., Nordheim, T. A., Elder, C. M., Castillo-Rogez, J. C., Neveu, M., et al. (2021). The Science Case for Spacecraft Exploration of the Uranian Satellites: Candidate Ocean Worlds in an Ice Giant System. *The Planetary Science Journal* 2(3), 120. CC BY 4.0.

METHOD

How this was checked

On October 13, 2026, we checked every statement, number and source on the original infographic, 73 items, against the Planetary Science Institute's release, the SETI Institute's write-up, ScienceDaily's version, the team's 2024 conference abstract, NASA and JPL data and the other numbered sources. Like the infographic's author, we couldn't read the paper: the publisher's site, which has listed the accepted manuscript as free to read since September 28, 2026, showed us a bot check, and we found no other copy or abstract. We measured the original drawings against their labels and re-ran the estimates. The check corrected several statements; the change log lists them.

After the page was built, a second reviewer who hadn't seen the drafting checked it against fresh copies of the sources and re-computed the interior, tide, orbit, coverage and drawing numbers; all reproduced. The changes that followed: the team's 2024 abstract doesn't say which resonance with Umbriel stretched Ariel's orbit, so the page no longer calls the 2:1 resonance studied in 2026 the team's or the likeliest explanation, only one candidate; the release's hedges ("growing evidence suggests", "might have existed") are kept; the claim that the fractures need an ocean now gives the model's two cases and its orbit premise; the 25–35 km of ice holds for rock near 3 g/cm³, while lighter rock leaves little room for a 170 km ocean; and a few smaller wording fixes.

The verdicts and the items tagged "Our analysis" are our own assessment, built on the cited sources: Ariel's interior and the ice left above a 170 km ocean, the tidal swing, and our reading of the model's trade-off. The drawings are our own, to scale where they say so.

This page was researched and written with Claude, an AI assistant made by Anthropic, and then re-checked against its sources in a separate verification pass.

The verdicts on this page

UNCONFIRMED — Rests on a preliminary result that hasn't been confirmed.

TRUE — The evidence supports the claim.

All ten verdicts, and how we check

CORRECTIONS

Corrections and changes

If we get something wrong, we fix it and record the change below with the date. If a correction changes a verdict, the log says what the old verdict was.

Change log

Oct 13, 2026 — Published on factchecked.science after a full check against the sources. Changes from the infographic: added our verdicts on four claims. The dek and assessment no longer call 170 km "the most extreme reading": it is the model's thin-ice solution, which the team's 2024 abstract presented as its result and which needs the least stretched orbit. Ariel's density is 1.539 g/cm³ (JPL), not near 1.6, so its water layer is about 197 km thick (150–240 km) rather than 186 (130–215), and with rock near 3 g/cm³ a 170 km ocean leaves about 27 km of ice rather than 16; the drawing is redrawn. "Half a moon, seen once" became "less than half": Voyager 2 imaged about 40% of the surface. "What stretched the orbit?" now says the team's 2024 abstract pointed to a resonance with Umbriel without saying which, and adds a 2026 study finding that one candidate, the 2:1 resonance, reaches only about 0.02. Tides weaken with the cube of the distance, rather than "scale with distance cubed", and step 2 no longer says Ariel flexes from ball-shaped to football-shaped and back. Magnetometry and gravity could find only an ocean that exists today, and a single close flyby might detect one, so "only an orbiter" was dropped. Today's and Europa's eccentricities are cited from JPL and NASA rather than worked back from the release (about 30–40 times today's). Patthoff's quotation is given in full; the SETI Institute item is a conversation with Strom and Patthoff, dated November 7, 2025; ScienceDaily's rewritten version is dated September 24, 2026; and the paper's citation is completed.