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1. New Study Traces Io's Volcanic Tides

Hundreds of volcanoes pockmark the surface of Io, the third largest of Jupiter's 78 known moons, and the only body in our solar system other than Earth where widespread volcanism can be observed. The source of the moon's inner heat is radically different than Earth's, making the moon a unique system to investigate volcanism.

A new study in the AGU journal *Geophysical Research Letters* finds Io's most powerful, persistent volcano, Loki Patera, brightens on a similar timescale to slight perturbations in Io's orbit caused by Jupiter's other moons, which repeat on an approximately 500-Earth-day cycle.

The new results are surprising because volcanoes on Io do not erupt in time with larger fluctuations in the far greater stresses inflicted on Io during the moon's 1.77-Earth-day orbit around Jupiter. Internal friction from these stresses generates the heat that powers Io's volcanoes, but fluctuating stresses during the short period of Io's orbit don't appear to squeeze magma to the surface.

The new study, which analyzed 271 nights of observations of Loki Patera from Hawaii's Keck and Gemini North telescopes from 2013–2018, and more sporadic observations dating back to 1987, suggests the gentler, 500-day cycle may act on the right timescale to move magma and bring it to the surface of the moon in an eruption.

"The stresses on Io's interior vary a lot during that 1.77-day orbit," said Katherine de Kleer, a planetary scientist at the California Institute of Technology and the lead author of the new study. "As far as anyone has been able to tell, there is no variation in Io's volcanoes on this 1.77-day scale, so it's a bit counterintuitive that we would see a response over the longer period, when the changes in stress are lower."
Understanding this dynamic may provide clues to Io's mysterious interior as well as the interiors of other bodies in the solar system warmed by a fluctuating pull of gravity, an effect called tidal heating.

"We know almost nothing about what Io's magma chambers and conduits are like, so Loki Patera's behavior is giving us a small window into an area where we currently have zero information," said de Kleer.

**Moon dance** Io has a hot interior because its tight orbit around Jupiter is not circular. The moon is stuck in an eccentric orbit because it resonates with Jupiter's largest moons, neighboring Europa and Ganymede, caught between their influence and the massive gravity of Jupiter.

![Orbital resonances of the Galilean moons of Jupiter. Credit: Matma Rex/Wikicommons](image)

Europa's orbit around Jupiter is twice as long as Io's, and Ganymede's orbit is twice as long as Europa's. This 1:2:4 rhythm means the pull of gravity from the other two moons repeats consistently as Io orbits around Jupiter.

Io's distance from Jupiter changes over the course of its elliptical orbit, so it experiences a different amount of Jupiter's gravity as it circles the massive planet. The shifting pull of Jupiter and the other moons stretches and compresses Io on its two-day orbit around Jupiter. This generates enough heat from friction within the materials of the moon's interior to melt rock into magma.

Researchers studying the more than 400 volcanoes on Io have looked for evidence that they erupt on the same beat. Such a fluctuation with daily orbit occurs on Saturn's moon Enceladus, which has an underground ocean that spurts out through cracks in the moon's frozen surface. Water geysers on Enceladus bloom largest when the moon is at its furthest point from Saturn and the fractures sourcing the geysers are being pulled open.

But the new study did not find evidence that Loki Patera keeps the same time as Io's two-day orbit around Jupiter. Instead, its brightness appears to fluctuate at a similar timescale to subtle perturbations in Io's orbit.

Although orbital resonance with Europa and Ganymede exerts the largest tidal effects on Io, the neighboring moons also slightly warp the shape of Io's orbit in cycles lasting 480–484 days and 461–464 days. Loki Patera appears to erupt on a cycle that is similar to this timeframe, according to the new study.

**Slow flow** De Kleer and her colleagues think the different dynamics on Io and Enceladus may have to do with the way fluids move through pores or cracks in rock. Magma is more like honey or toothpaste than water. It does not respond as quickly as water to squeezing. The period of Io's orbit may be too short for tidal effects in the moon's interior to erupt onto the surface.

"The magma in Io's crust takes time to flow," said Francis Nimmo, a geophysicist at the University of California Santa Cruz and co-author on the new paper. "If you squeeze and stretch the crust rapidly, nothing happens; but if you squeeze and stretch it more slowly, the magma has time to move far enough to fill a volcanic conduit, causing an eruption. It's similar to the way you can run on wet sand, but if you walk slowly your feet sink."

What scientists learn about tidal heating effects from studying Io could be applicable to Europa and other bodies throughout the solar system that are tidally heated, according to the authors of the new study.

Source: [American Geophysical Union](https://www.agu.org)

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Welcome to the early solar system. Just after the planets formed more than 4.5 billion years ago, our cosmic neighborhood was a chaotic place. Waves of comets, asteroids and even proto-planets streamed toward the inner solar system, with some crashing into Earth on their way. These impacts were so violent that they melted the rocks at the planet’s surface.

Now, a team led by CU Boulder geologist Stephen Mojzsis has laid out a new timeline for this violent period in our planet’s history.

In a study published today, the researchers homed in on a phenomenon called “giant planet migration.” That’s the name for a stage in the evolution of the solar system in which the largest planets, for reasons that are still unclear, began to move away from the sun.

Drawing on records from asteroids and other sources, the group estimated that this solar system-altering event occurred 4.48 billion years ago—much earlier than some scientists had previously proposed.

The findings, Mojzsis said, could provide scientists with valuable clues around when life might have first emerged on Earth.
“We know that giant planet migration must have taken place in order to explain the current orbital structure of the outer solar system,” said Mojzsis, a professor in the Department of Geological Sciences. “But until this study, nobody knew when it happened.”

**Imbrium Basin**

It’s a debate that, at least in part, has its origins in the Apollo space program.

When astronauts landed on the near side of the moon in the late 1960s and early 1970s, they collected a lot of rocks. But those geologic samples were also puzzling: Many seemed to be only 3.9 billion years old, hundreds of millions of years younger than the moon itself.

To explain the seemingly anachronistic rock ages, some researchers suggested that our moon—and Earth—were slammed by a surge of comets and asteroids around that time. They called this spike in impacts, appropriately, the “late lunar cataclysm.”

There was just one problem with the theory, Mojzsis added. When scientists inspected the patterns of craters on the moon, Mars and Mercury they couldn't find any evidence for such a surge.

“It turns out that the part of the moon we landed on is very unusual,” Mojzsis said. “It is strongly affected by one big impact, the Imbrium Basin, that is about 3.9 billion years old and affects nearly everything we sampled.”

To get around that bias, the researchers decided to step away from the inner solar system. Instead, they compiled the ages from an exhaustive database of meteorites that had crash landed on Earth.

“The surfaces of the inner planets have been extensively reworked both by impacts and indigenous events until about 4 billion years ago,” said study coauthor Ramon Brasser of the Earth-Life Science Institute in Tokyo. “The same is not true for the asteroids. Their record goes back much further.”

The team discovered that, no matter how much they searched, they couldn't find a single asteroid or chunk of planetary rock that recorded a cataclysmic bombardment event younger than about 4.5 billion years old.

*Depiction of large asteroids striking Earth, which, during parts of its early history, would have had a much thicker atmosphere than it does today. (Credits: NASA with modifications by Stephen Mojzsis)*

“The 3.9-billion-year ages that dominated the lunar samples were nowhere to be seen in the meteorites,” Brasser said.
For the team, that presented only one possibility: The solar system must have experienced a major bombardment just before that cut-off date. Very large impacts, Mojzsis said, can melt rocks and variably reset their radioactive ages, a bit like shaking an etch-a-sketch.

**Planets on the move**

And the cause of all that carnage? Mojzsis and his colleagues believe that it comes down to Jupiter, Saturn, Uranus and Neptune.

He explained that these goliath planets likely formed much closer together than they are today. Using computer simulations, however, his group demonstrated that those bodies started to creep toward their present locations about 4.48 billion years ago.

In the process, they scattered the debris in their wake, sending some of it hurtling toward Earth and its then-young moon.

The bombardment history of the solar system “began with the comets that came screaming into the inner solar system. As they did, they reset the age of the crusts of the Earth, Moon and Mars,” Mojzsis said. “The next wave were planetesimals left over from the formation of the inner planets. The last group to arrive were the asteroids, which continue to leak toward us today.”

The findings, he added, open up a new window for when life may have evolved on Earth. Based on the team’s results, our planet may have been calm enough to support living organisms as early as 4.4 billion years ago. The oldest known fossil shapes today are just 3.5 billion years old.

“The only way to sterilize the Earth completely is to melt the crust all at once,” Mojzsis said. “We’ve shown that this hasn’t happened since giant planet migration commenced.”

*Other co-authors on the study include Nigel Kelly, formerly of CU Boulder; Oleg Abramov at the Planetary Science Institute; and Stephanie Werner at the University of Oslo.*

![The Hadley Crater on Mars. (Credits: NASA; ESA)](image)
3. Still NASA Mission Selects Final Four Site Candidates for Asteroid Sample Return

Pictured are the four candidate sample collection sites on asteroid Bennu selected by NASA’s OSIRIS-REx mission. Site Nightingale (top left) is located in Bennu’s northern hemisphere. Sites Kingfisher (top right) and Osprey (bottom left) are located in Bennu’s equatorial region. Site Sandpiper (bottom right) is located in Bennu’s southern hemisphere. In December, one of these sites will be chosen for the mission’s touchdown event. Credits: NASA/University of Arizona

After months grappling with the rugged reality of asteroid Bennu’s surface, the team leading NASA’s first asteroid sample return mission has selected four potential sites for the Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer (OSIRIS-REx) spacecraft to “tag” its cosmic dance partner.

Since its arrival in December 2018, the OSIRIS-REx spacecraft has mapped the entire asteroid in order to identify the safest and most accessible spots for the spacecraft to collect a sample. These four sites now will be studied in further detail in order to select the final two sites – a primary and backup – in December.

The team originally had planned to choose the final two sites by this point in the mission. Initial analysis of Earth-based observations suggested the asteroid’s surface likely contains large “ponds” of fine-grain material. The spacecraft’s earliest images, however, revealed Bennu has an especially rocky terrain. Since then, the asteroid’s boulder-filled topography has created a challenge for the team to identify safe areas containing sampleable material, which must be fine enough – less than 1 inch (2.5 cm) diameter – for the spacecraft’s sampling mechanism to ingest it.

The original mission schedule intentionally included more than 300 days of extra time during asteroid operations to address such unexpected challenges. In a demonstration of its flexibility and ingenuity in response to Bennu’s...
surprises, the mission team is adapting its site selection process. Instead of down-selecting to the final two sites this summer, the mission will spend an additional four months studying the four candidate sites in detail, with a particular focus on identifying regions of fine-grain, sampleable material from upcoming, high-resolution observations of each site. The boulder maps that citizen science counters helped create through observations earlier this year were used as one of many pieces of data considered when assessing each site’s safety. The data collected will be key to selecting the final two sites best suited for sample collection.

In order to further adapt to Bennu’s ruggedness, the OSIRIS-REx team has made other adjustments to its sample site identification process. The original mission plan envisioned a sample site with a radius of 82 feet (25 m). Boulder-free sites of that size don’t exist on Bennu, so the team has instead identified sites ranging from 16 to 33 feet (5 to 10 m) in radius. In order for the spacecraft to accurately target a smaller site, the team reassessed the spacecraft’s operational capabilities to maximize its performance. The mission also has tightened its navigation requirements to guide the spacecraft to the asteroid’s surface, and developed a new sampling technique called “Bullseye TAG,” which uses images of the asteroid surface to navigate the spacecraft all the way to the actual surface with high accuracy.

The four candidate sample sites on Bennu are designated Nightingale, Kingfisher, Osprey, and Sandpiper – all birds native to Egypt. The naming theme complements the mission’s two other naming conventions – Egyptian deities (the asteroid and spacecraft) and mythological birds (surface features on Bennu). The four sites are diverse in both geographic location and geological features. While the amount of sampleable material in each site has yet to be determined, all four sites have been evaluated thoroughly to ensure the spacecraft’s safety as it descends to, touches and collects a sample from the asteroid’s surface.

Nightingale is the northern-most site, situated at 56 degrees north latitude on Bennu. There are multiple possible sampling regions in this site, which is set in a small crater encompassed by a larger crater 459 feet (140 m) in diameter. The site contains mostly fine-grain, dark material and has the lowest albedo, or reflection, and surface temperature of the four sites.

Kingfisher is located in a small crater near Bennu’s equator at 11 degrees north latitude. The crater has a diameter of 26 feet (8 m) and is surrounded by boulders, although the site itself is free of large rocks. Among the four sites, Kingfisher has the strongest spectral signature for hydrated minerals.

Osprey is set in a small crater, 66 feet (20 m) in diameter, which is also located in Bennu’s equatorial region at 11 degrees north latitude. There are several possible sampling regions within the site. The diversity of rock types in the surrounding area suggests that the regolith within Osprey may also be diverse. Osprey has the strongest spectral signature of carbon-rich material among the four sites.

Sandpiper is located in Bennu’s southern hemisphere, at 47 degrees south latitude. The site is in a relatively flat area on the wall of a large crater 207 ft (63 m) in diameter. Hydrated minerals are also present, which indicates that Sandpiper may contain unmodified water-rich material.

This fall, OSIRIS-REx will begin detailed analyses of the four candidate sites during the mission’s reconnaissance phase. During the first stage of this phase, the spacecraft will execute high passes over each of the four sites from a distance of 0.8 miles (1.29 km) to confirm they are safe and contain sampleable material. Closeup imaging also will map the features and landmarks required for the spacecraft’s autonomous navigation to the asteroid’s surface. The team will use the data from these passes to select the final primary and backup sample collection sites in December.

The second and third stages of reconnaissance will begin in early 2020 when the spacecraft will perform passes over the final two sites at lower altitudes and take even higher resolution observations of the surface to identify features, such as groupings of rocks that will be used to navigate to the surface for sample collection. OSIRIS-REx sample collection is scheduled for the latter half of 2020, and the spacecraft will return the asteroid samples to Earth on Sept. 24, 2023.

Source: NASA

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The Night Sky

Mercury puts in a great dawn apparition this month, reaching greatest western elongation on August 10th at the Gemini–Cancer border. The planet stands about 7° high 45 minutes before sunrise in the northeastern sky. This view depicts the scene on August 8th when the planet shines at magnitude 0.2. On the morning of the 13th, Mercury, Pollux, and Castor will form a nearly straight line.

Source: Sky and Telescope

Tuesday, August 13

- The nights around full Moon, such as now, are traditionally considered the worst for lunar observing. But not if your interest is crater rays! These show best under high, shadowless illumination. To go exploring, see Chuck Wood's "Unruly Crater Rays" in the August Sky & Telescope, page 52. Do you know about the hill-blocked ray pattern of Kepler?

Wednesday, August 14

- Full Moon tonight and tomorrow night. The actual moment of full Moon is 8:29 a.m. tomorrow morning EDT. So for evening skywatchers in the time zones of the Americas, both this evening and tomorrow evening qualify as "full moon" about equally.

Tonight the Moon is in dim Capricornus. Tomorrow it'll be just across the constellation border into dim Aquarius.

Thursday, August 15

- Different people have an easier or harder time seeing star colors, especially subtle ones. To me, the tints of bright stars stand out a little better on a bright sky background — such as we have with the moonlight tonight.

For instance, the two brightest stars of summer are Vega, overhead soon after dark, and Arcturus, shining in the west. Vega is white with just a touch of blue. Arcturus is a yellow-orange giant. Do their colors stand out a little better for you in moonlight or in late twilight?

Binoculars, of course, always make star colors easier.

Friday, August 16

- As August proceeds and nights begin to turn chilly, the Great Square of Pegasus lifts up in the east, balancing on one corner. Its stars are only 2nd and 3rd magnitude, and your fist at arm's length fits inside it. Late this evening the waning gibbous Moon rises below it.

From the Square's left corner extends the main line of the constellation Andromeda: three stars (including the corner) about as bright as those forming the Square.
ISS Sighting Opportunities (from Denver)

ISS sightings are not possible at Denver through Friday Aug 23, 2019

Sighting information for other cities can be found at NASA’s Satellite Sighting Information

NASA-TV Highlights  (all times Eastern Time Zone)

August 13, Tuesday

• 2:10 p.m. – International Space Station Program In-Flight Event for the European Space Agency with the Stockholm Culture Festival and ESA astronaut Luca Parmitano (Public Channel with interpretation, Media Channel in native language)

August 14, Wednesday

• 12:25 p.m. – International Space Station Program In-Flight Event with the Bustle Digital Group and NASA astronaut Christina Koch (All Channels)

August 16, Friday

• 2 p.m. – International Space Station Expedition 60 International Docking Adapter Spacewalk Preview Briefing (All Channels)

Watch NASA TV online by going to the NASA website.
Space Calendar

- Aug 13 - **Aten Asteroid 2017 QK18** Near-Earth Flyby (0.076 AU)
- Aug 13 - **Apollo Asteroid 5143 Heracles Closest Approach To Earth** (0.673 AU)
- Aug 13 - **Asteroid 10799 Yucatan** Closest Approach To Earth (1.080 AU)
- Aug 13 - **Aten Asteroid 5381 Sekmet Closest Approach To Earth** (1.292 AU)
- Aug 13 - **Asteroid 19367 Pink Floyd** Closest Approach To Earth (1.319 AU)
- Aug 13 - **Asteroid 48472 Mossbauer** Closest Approach To Earth (1.429 AU)
- Aug 13-17 - **1st NARIT-EACOA Summer Workshop on Astrostatistics & Astroinformatics**, Chgian Mai, Thailand
- **Aug 14 - Chandrayaan 2, Trans-Lunar Injection Maneuver**
- Aug 14 - **Asteroid 4864 Nimoy** Closest Approach To Earth (1.034 AU)
- Aug 14 - **Asteroid 278141 Tatooine** Closest Approach To Earth (1.623 AU)
- Aug 14 - **Asteroid 72432 Kimrobinson** Closest Approach To Earth (1.652 AU)
- Aug 14 - **Colloquium: The Faint Extragalactic Radio Background**, Sydney, Australia
- Aug 14 - 20th Anniversary (1999), **Galileo**, Callisto 22 Flyby
- Aug 15 - **Asteroid 9937 Triceratops** Closest Approach To Earth (0.996 AU)
- Aug 15 - **Frontier Development Lab (FDL) AI Results Showcase 2019**, Sunnyvale, California
- **Aug 16 - BlackSky Global 4 / BRO 1 Electron Launch**
- Aug 16 - **Apollo Asteroid 2019 PJ** Near-Earth Flyby (0.022 AU)
- Aug 16 - **Amor Asteroid 3757 Anagolay Closest Approach To Earth** (1.237 AU)
- Aug 16 - **Asteroid 6524 Baalke** Closest Approach To Earth (1.312 AU)
- Aug 16-24 - **5th Indo-French Astronomy School (IFAS5): Spectroscopy & Spectrographs**, Pune, India
- **Aug 17 - Qiancheng 01 / Tiangi 2 Jeilong-1 F1 Launch**
- Aug 17 - **Comet 112P/Urata-Niiijima At Opposition** (1.394 AU)
- Aug 17 - **Atira Asteroid 481817 (2008 UL90) Closest Approach To Earth** (0.577 AU)
- Aug 17 - **Apollo Asteroid 141593 (2002 HK12) Near-Earth Flyby** (0.062 AU)
- Aug 17 - **Galaxy Forum Hawaii**, Hilo, Hawaii
- Aug 17-18 - **Course: Missile Propulsion**, Indianapolis, Indiana

Source: [JPL Space Calendar](https://www.jpl.nasa.gov/)
Food for Thought

Traces of One of the Oldest Stars in the Universe Found Inside Another Star

Artistic impression of a star going supernova, casting its chemically-enriched contents into the universe. In the case of Bob’s (SMSS J160540.18-144323.1) ancestor, most of those chemically-enriched contents were not ejected, but fell back into the supernova’s remnants. Credit: NASA/Swift/Skyworks Digital/Dana Berry

Despite all we know about the formation and evolution of the Universe, the very early days are still kind of mysterious. With our knowledge of physics we can shed some light on the nature of the earliest stars, even though they’re almost certainly long gone.

Now a new discovery is confirming what scientists think they know about the early Universe, by shedding light on a star that’s still shining.

This new discovery is centered around a star in our very own Milky Way. It’s called SMSS J160540.18-144323.1 (but we’re just going to call it ‘Bob’ for the purposes of this article.) Bob is about 35,000 light years away. Bob bears the marks of its very early ancestor, one of the Universe’s first generation of stars that was extremely low in metal and that lived in the Universe’s early days.

Astronomers talk about stars in terms of metallicity. In astronomical terms, a metal is any element heavier than hydrogen, helium, and lithium, all of which were created in the Big Bang. Early stars contained only those three light elements because the other heavier elements hadn’t been created yet. Elements heavier than the first three were created in successive generations of stars.

This first generation of metal-free stars is called Population III. They are largely hypothetical, but our knowledge of astrophysics says they have to have existed. Population III stars were extremely massive, hot
stars that didn’t last long. The only way we can learn anything about them is to study the stars that formed out of the material they ejected when they died. It’s kind of like forensic astrophysics.

Now back to Bob.

Dr. Thomas Nordlander is an astronomer at the Australian National University (ANU.) He’s from the ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions (ASTRO 3D) at the ANU Research School of Astronomy and Astrophysics (RSAA). That’s a mouthful, but the main point is that Nordlander is an accomplished astronomer who has authored and co-authored 15 scientific papers. One of his specialties is extremely low-metal stars, and as an astronomer at ASU he has access to the Siding Spring Observatory.

Dr. Nordlander was observing with the ANU Skymapper and the 2.3 meter telescope at Siding Spring when he discovered Bob.

Bob was different, unexpected. Bob’s extremely low metallicity was surprising. According to Nordlander, Bob is like a time machine, because the low metallicity is a glimpse back in time to the conditions that formed the star.

“We’ve found a time machine that takes us back to the Universe’s earliest stars,” said Dr. Nordlander.

Bob is unusual because its iron content is almost nil. With an iron level 1.5 million times lower than the Sun, it’s more similar to a Population III star than it is to stars from its own generation. In fact, Bob has the lowest iron content ever detected in a star.

“This incredibly anemic star, which likely formed just a few hundred million years after the Big Bang, has iron levels 1.5 million times lower than that of the Sun,” Nordlander said. “In this star, just one atom in every 50 billion is iron – that’s like one drop of water in an Olympic swimming pool.”

Here’s what Nordlander and his colleague Professor Martin Asplund think happened:

Bob had an ancient progenitor, a Population III star that was typical of its time, with only helium, hydrogen and maybe a little lithium. It was about 10 times more massive than our Sun, and stars that massive burn through their fuel quickly and don’t have long lives.

When this ancient ancestor of Bob reached the end of its life, it exploded as a supernova. Bob’s ancestor would’ve created some heavier elements, which in most cases would’ve been ejected into interstellar space and helped form the next generation of stars. But in this case, the explosion was not that powerful.

“We think the supernova energy of the ancestral star was so low that most of the heavier elements fell back into a very dense remnant created by the explosion. Only a tiny fraction of the elements heavier than carbon escaped into space and helped to form the very old star <Bob> that we found.”

In some respects, Bob is like other halo stars in terms of composition. But alongside its low iron content, it has some other quirks.

Bob has an elevated level of carbon. According to the authors of the paper, this high carbon level indicates “enrichment from a Population III mixing-and-fallback supernova.” Though there could be other reasons for this carbon level, like a companion star, the authors rule them out. “Alternative explanations are unsatisfactory. The elevated abundance of carbon could be due to pollution from an intermediate mass companion star, but models predict that this also leads to similar enhancement of nitrogen.” But there is no nitrogen enhancement in Bob.

Another possible explanation is contamination from the Interstellar Medium (ISM,) something the authors also dismiss. “An initially metal-free, or perhaps metal-poor but carbon-normal, star could also be polluted by
accretion from the ISM. Again, models of this process predict significant enhancement of nitrogen alongside carbon relative to the depletion of refractory iron-peak elements, and can likewise be ruled out.”

So Bob itself formed a few hundred million years after the Big Bang, at a time when stars should have formed with a higher metallicity than Bob has. And Bob’s uncharacteristically low iron level tells us something about its even more ancient ancestor. When that ancient ancestor went supernova, it would’ve synthesized much heavier elements through nucleosynthesis.

![Color-coded periodic table](https://commons.wikimedia.org/wiki/index.php?curid=31761437)

*This color-coded periodic table helps explain where the elements come from. [Click to Enlarge.](https://commons.wikimedia.org/wiki/index.php?curid=31761437)*

But due to the weakness of its supernova explosion, those heavier elements weren’t blasted out into space. When Bob formed in the aftermath of that supernova explosion, there were no metals around. They’d all been sucked back into the supernova remnant, meaning Bob was starved of the iron and other heavy elements astronomers expect to see in stars Bob’s age.

It’s extremely unlikely that any of the first, metal-poor stars from the first days of the Universe have survived to this day. But we can see their fingerprints in stars like Bob.

“The good news is that we can study the first stars through their children – the stars that came after them like the one we’ve discovered,” Asplund said.

Source: [Universe Today](https://www.universetoday.com/)

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Atlas at Dawn
Image Credit & Copyright: Michael Seeley

Explanation: This single, 251-second long exposure follows the early flight of an Atlas V rocket on August 8, streaking eastward toward the dawn from Cape Canaveral Air Force Station, planet Earth. The launch of the United Launch Alliance rocket was at 6:13am local time. Sunrise was not until 6:48am, but the rocket's downrange plume at altitude is brightly lit by the Sun still just below the eastern horizon. Waters of the Indian River Lagoon in Palm Shores, Florida reflect subtle colors and warming glow of the otherwise calm, predawn sky. The mighty Atlas rocket carried a military communications satellite into Earth orbit.

Of course, this weekend the streaks you see in clear skies before the dawn could be Perseid Meteors

Right: Credit: SpaceflightNow.com

Source: NASA APOD