Space News Update

— July 3, 2020 —

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1. Radar Points to Moon Being More Metallic Than Researchers Thought

What started out as a hunt for ice lurking in polar lunar craters turned into an unexpected finding that could help clear some muddy history about the Moon's formation.

Team members of the Miniature Radio Frequency (Mini-RF) instrument on NASA's Lunar Reconnaissance Orbiter (LRO) spacecraft found new evidence that the Moon's subsurface might be richer in metals, like iron and titanium, than researchers thought. That finding, published July 1 in Earth and Planetary Science Letters, could aid in drawing a clearer connection between Earth and the Moon.

"The LRO mission and its radar instrument continue to surprise us with new insights about the origins and complexity of our nearest neighbor," said Wes Patterson, Mini-RF principal investigator from the Johns Hopkins Applied Physics Laboratory (APL) in Laurel, Maryland, and a study coauthor.

Substantial evidence points to the Moon as the product of a collision between a Mars-sized protoplanet and young Earth, forming from the gravitational collapse of the remaining cloud of debris. Consequently, the Moon's bulk chemical composition closely resembles that of Earth.

Look in detail at the Moon's chemical composition, however, and that story turns murky. For example, in the bright plains of the Moon's surface, called the lunar highlands, rocks contain smaller amounts of metal-bearing minerals relative to Earth. That finding might be explained if Earth had fully differentiated into a core, mantle and crust before the impact, leaving the Moon largely metal-poor. But turn to the Moon's maria — the large, darker plains — and the metal abundance becomes richer than that of many rocks on Earth.

This discrepancy has puzzled scientists, leading to numerous questions and hypotheses regarding how much the impacting protoplanet may have contributed to the differences. The Mini-RF team found a curious pattern that could lead to an answer.

Using Mini-RF, the researchers sought to measure an electrical property within lunar soil piled on crater floors in the Moon's northern hemisphere. This electrical property is known as the dielectric constant, a number that compares the relative abilities of a material and the vacuum of space to transmit electric fields, and could help locate ice lurking in the crater shadows. The team, however, noticed this property increasing with crater size.

For craters approximately 1 to 3 miles (2 to 5 kilometers) wide, the dielectric constant of the material steadily increased as the craters grew larger, but for craters 3 to 12 miles (5 to 20 kilometers) wide, the property remained constant.

“It was a surprising relationship that we had no reason to believe would exist,” said Essam Heggy, coinvestigator of the Mini-RF experiments from the University of Southern California in Los Angeles and lead author of the published paper.

Discovery of this pattern opened a door to a new possibility. Because meteors that form larger craters also dig deeper into the Moon’s subsurface, the team reasoned that the increasing dielectric constant of the dust in larger craters could be the result of meteors excavating iron and titanium oxides that lie below the surface. Dielectric properties are directly linked to the concentration of these metal minerals.

If their hypothesis were true, it would mean only the first few hundred meters of the Moon’s surface is scant in iron and titanium oxides, but below the surface, there’s a steady increase to a rich and unexpected bonanza.

Comparing crater floor radar images from Mini-RF with metal oxide maps from the LRO Wide-Angle Camera, Japan’s Kaguya mission and NASA’s Lunar Prospector spacecraft, the team found exactly what it had suspected. The larger craters, with their increased dielectric material, were also richer in metals, suggesting that more iron and titanium oxides had been excavated from the depths of 0.3 to 1 mile (0.5 to 2 kilometers) than from the upper 0.1 to 0.3 miles (0.2 to 0.5 kilometers) of the lunar subsurface.

“This exciting result from Mini-RF shows that even after 11 years in operation at the Moon, we are still making new discoveries about the ancient history of our nearest neighbor,” said Noah Petro, the LRO project scientist at NASA’s Goddard Space Flight Center in Greenbelt, Maryland. “The MINI-RF data is incredibly valuable for telling us about the properties of the lunar surface, but we use that data to infer what was happening over 4.5 billion years ago!”

These results follow recent evidence from NASA’s Gravity Recovery and Interior Laboratory (GRAIL) mission that suggests a significant mass of dense material exists just a few tens to hundreds of kilometers beneath the Moon’s enormous South Pole-Aitken basin, indicating that dense materials aren’t uniformly distributed in the Moon’s subsurface.

The team emphasizes that the new study can’t directly answer the outstanding questions about the Moon’s formation, but it does reduce the uncertainty in the distribution of iron and titanium oxides in the lunar subsurface and provide critical evidence needed to better understand the Moon’s formation and its connection to Earth.

“It really raises the question of what this means for our previous formation hypotheses,” Heggy said.

Anxious to uncover more, the researchers have already started examining crater floors in the Moon’s southern hemisphere to see if the same trends exist there.

LRO is managed by NASA’s Goddard Space Flight Center in Greenbelt, Maryland for the Science Mission Directorate at NASA Headquarters in Washington. Mini-RF was designed, built and tested by a team led by APL, Naval Air Warfare Center, Sandia National Laboratories, Raytheon and Northrop Grumman.

For more information on LRO, visit https://www.nasa.gov/lro.

Source: NASA Return to Contents

2. Launch of NASA Mars Rover Delayed Again, 2 Weeks Left to Fly

NASA has delayed the launch of its newest Mars rover yet again—to the end of July at the earliest—this time for a rocket issue.

If the Perseverance rover isn't on its way by mid-August, it will have to wait until 2022 when Earth and Mars are back in proper alignment, costing NASA close to $500 million for the delay alone.

Managers are now targeting no earlier than July 30 for a liftoff from Cape Canaveral, eating up half of the monthlong launch window. The good news is that NASA is trying to eke out more time in this summer's launch opportunity, now lasting until at least Aug. 15. The chance to fly to Mars comes up only every 26 months.

It is NASA's most ambitious Mars mission yet, totaling around $3 billion. Besides seeking signs of past microscopic Martian life, Perseverance will gather rocks and soil for eventual return to Earth.

Rocket maker United Launch Alliance needs extra time to deal with a liquid oxygen sensor line that showed questionable readings during a recent practice countdown, officials said Tuesday. Previous technical concerns—including crane trouble at the pad—bumped the launch from the original July 17 to the 20th and then 22nd.

Perseverance will still attempt a touchdown next February in an ancient river delta at Mars, regardless of when it launches.

The United Arab Emirates and China, meanwhile, still are pressing ahead with launches this month or next of Mars spacecraft. Russia and the European Space Agency had to bow out, delaying their Mars rover until 2022 because of delayed spacecraft testing and travel limitations due to the coronavirus pandemic.

Source: Phys.org

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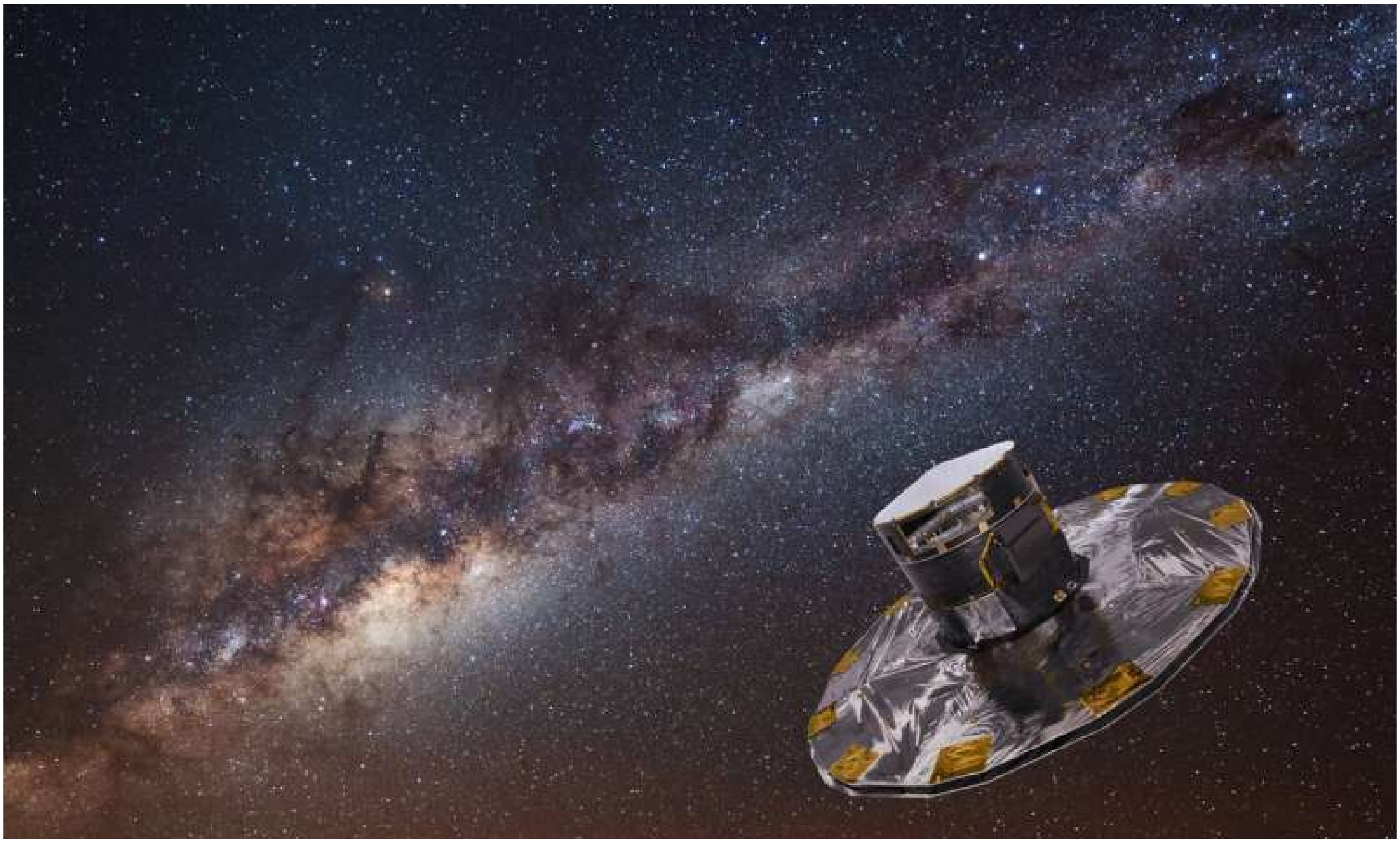
3. **Gaia Revolutionizes Asteroid Tracking**



ESA's Gaia space observatory is an ambitious mission to construct a three-dimensional map of our galaxy by making high-precision measurements of over one billion stars. However, on its journey to map distant suns, Gaia is revolutionising a field much closer to home. By accurately mapping the stars, it is helping researchers track down lost asteroids.

Using stars to spot asteroids

Gaia charts the galaxy by repeatedly scanning the entire sky. Over the course of its planned mission, it observed each of its more than one billion target stars around 70 times to study how their position and brightness change over time.

The stars are so far from Earth that their movements between images are very small, hence why Gaia has to measure their positions so accurately to even notice a difference. However, sometimes Gaia spots faint light sources that move considerably from one image of a certain region of the sky to the next, or are even only spotted in a single image before disappearing.

To move across Gaia's field of view so quickly, these objects must be located much closer to Earth.

By checking the positions of these objects against the catalogues of known Solar System bodies, many of these objects turn out to be known asteroids. Some, however, are identified as potentially new detections and are then followed up by the astronomy community through the Gaia Follow-Up Network for Solar System Objects. Through this process, Gaia has successfully discovered new asteroids.

Lost and found

These direct asteroid observations are important for solar system scientists. However, Gaia's highly accurate measurements of the positions of stars provide an even more impactful, but indirect, benefit for asteroid tracking.

"When we observe an asteroid, we look at its motion relative to the background stars to determine its trajectory and predict where it will be in the future," says Marco Micheli from ESA's Near-Earth Object Coordination Centre. "This means that the more accurately we know the positions of the stars, the more reliably we can determine the orbit of an asteroid passing in front of them."

In collaboration with the European Southern Observatory (ESO), Marco's team took part in an observation campaign targeting 2012 TC4, a small asteroid that was due to pass by the Earth. Unfortunately, since the asteroid was first spotted in 2012, it had become fainter and fainter as it receded form Earth, eventually becoming unobservable. Where it would appear in the sky at the time of the upcoming campaign was not well known.

"The possible region of the sky where the asteroid might appear was larger than the area that the telescope could observe at one time," says Marco. "So we had to find a way to improve our prediction of where the asteroid would be."

"I looked back at the initial observations from 2012. Gaia had since made more accurate measurements of the positions of some of the stars in the background of the images, and I used these to update our understanding of the asteroid's trajectory and predict where it would appear."

"We pointed the telescope towards the predicted area of the sky using the data from Gaia and we found the asteroid on our first attempt."

"Our next goal was to accurately measure the asteroid's position, but we had very few stars in our new image to use as a reference. There were 17 stars listed in an older catalogue and only four stars measured by Gaia. I made calculations using both sets of data."

"Later in the year, when the asteroid had been observed multiple times by other teams and its trajectory was better known, it became clear that the measurements I made using just four Gaia stars had been much more accurate than the ones using the 17 stars. This was really amazing."

Keeping Earth safe

This same technique is being applied to asteroids that were never lost, allowing researchers to use data from Gaia to determine their trajectories and physical properties more accurately than ever before.

This is helping them update asteroid population models and deepen our understanding of how asteroid orbits develop, for example, by measuring subtle dynamical effects that play a key role in pushing small asteroids into orbits that could see them collide with Earth.

Dancing with daylight

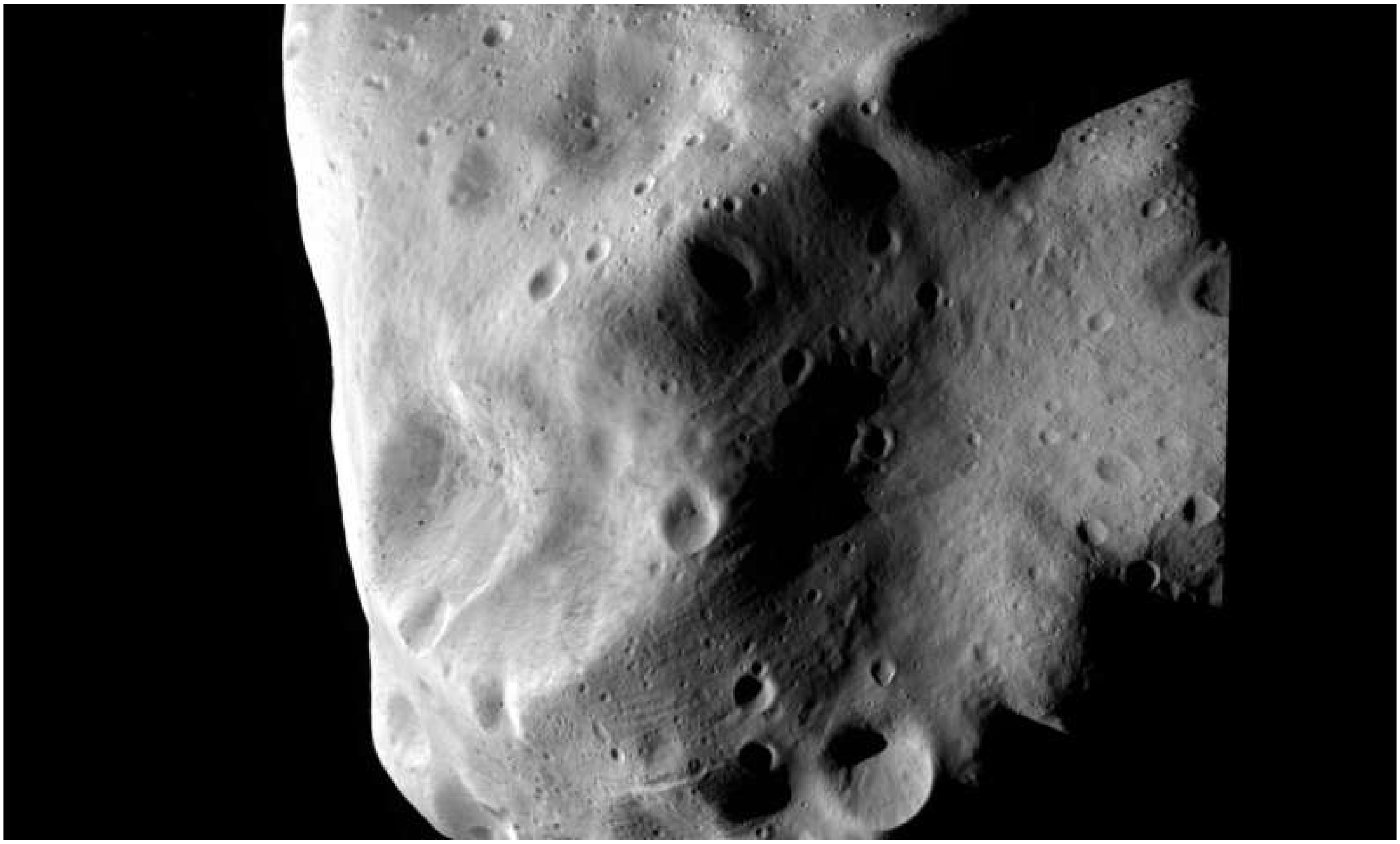
In order to make such accurate measurements of the positions of other stars, Gaia has a complicated relationship with our own.

Gaia orbits around the second Lagrange point, L2, of the Sun-Earth system. This location keeps the Sun, Earth and Moon all behind Gaia, allowing it to observe a large portion of the sky without their interference. It is also in an even thermal radiation environment and experiences a stable temperature.

However, Gaia must not fall entirely into Earth's shadow, as the spacecraft still depends on solar power. As the orbit around the L2 point is unstable, small disturbances can build up and see the spacecraft heading for an eclipse.

Gaia's flight control team at ESA's ESOC mission control centre in Darmstadt are responsible for making corrections to the spacecraft's trajectory to keep it in the correct orbit and out of Earth's shadow. They ensure that Gaia remains one of the most stable and accurate spacecraft ever. On 16 July 2019, the team successfully performed a crucial eclipse avoidance manoeuvre, moving Gaia into the extended phase of its mission and allowing it to keep scanning the sky for several more years.

Explore further: Gaia's asteroid discoveries



Source: Phys.org

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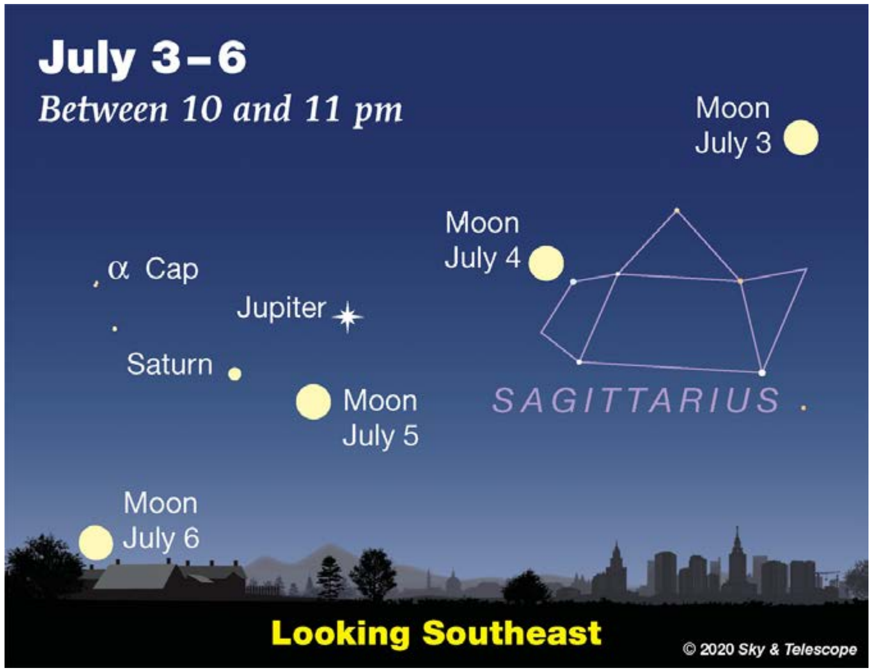
The Night Sky

FRIDAY, JULY 3

■ To skywatchers whose view low in the north is obstructed, "Cassiopeia in July" might sound as wrong as Christmas in July. But already Cas has passed its lowest evening position of the year, and it is gradually gaining altitude toward the coming fall and winter. Look for its flattened W shape low in the north-northeast these nights. The W is no longer level.



SATURDAY, JULY 4

■ Full Moon (exactly full at 12:44 a.m. tonight EDT). This evening the Moon shines next to the handle of the Sagittarius Teapot, as shown above. How much of the Teapot can you see through the moonlight? It's about the size of your fist at arm's length.

Much easier are bright Jupiter and Saturn, shining to the Moon's lower left.

■ The Moon will undergo a very slight penumbral eclipse tonight for most of the Americas, probably undetectable by eye. The Moon's northern edge will skim through the outermost pale fringe of Earth's shadow, with maximum eclipse coming at 12:31 a.m. Sunday morning EDT; 9:31 p.m. Saturday evening PDT (that's 4:31 July 5th UT). For much of the West Coast, the Moon at that time will be low in the east in evening twilight. Farther east, and for all of Central and South America, the Moon will be higher in a dark sky. Map and details.

At mid-eclipse the Moon's northern limb will extend only a third of the way across Earth's penumbra. Traditionally, a penumbral eclipse is considered invisible unless the Moon's limb reaches halfway across the penumbra. But telescopic photos, processed to reveal a very weak contrast change, might succeed in bringing out evidence of this event if your eyes don't.

■ Today Earth is at aphelion, its farthest from the Sun for the year. We're one part in 30 farther from the Sun than at perihelion in January.

SUNDAY, JULY 5

■ The Moon hangs in a triangle under Jupiter and Saturn this evening, as shown above.

MONDAY, JULY 6

■ Starry Scorpius is sometimes called "the Orion of Summer" for its brightness, its blue-white giant stars, and its prominent red supergiant (Antares in the case of Scorpius, Betelgeuse for Orion). But Scorpius passes a lot lower across the southern sky than Orion does, for those of us at mid-northern latitudes. That means it has only one really good evening month: July.

Catch Scorpius due south soon after dark, before it starts to tilt lower toward the southwest. It's full of deep-sky objects to hunt out with good charts using a telescope or even binoculars. Of course, you'll need to know how to use sky charts with a telescope.

Source: Sky & Telescope Return to Contents

ISS Sighting Opportunities

For Denver:

Date	Visible	Max Height	Appears	Disappears
Sat Jul 4, 3:07 AM	2 min	37°	37° above NW	23° above NNE
Sat Jul 4, 4:44 AM	2 min	12°	10° above NW	11° above N
Sun Jul 5, 2:21 AM	1 min	30°	30° above NE	14° above NE
Sun Jul 5, 3:55 AM	3 min	15°	10° above NW	14° above N
Mon Jul 6, 1:34 AM	< 1 min	14°	14° above NE	11° above NE
Mon Jul 6, 3:07 AM	2 min	19°	15° above NW	17° above N
Mon Jul 6, 4:46 AM	1 min	10°	10° above NNW	10° above N

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

NASA-TV Highlights
(all times Eastern Daylight Time)

July 3, Friday
8 a.m., 2 p.m., 7 p.m. - Replay of International Space Station Expedition 63-64 Crew News Conference (Rubins, Ryzhikov, Kud-Sverchkov) (All Channels)

July 4, Saturday
9 a.m., 4 p.m., 9 p.m. - Replay of International Space Station Expedition 63-64 Crew News Conference (Rubins, Ryzhikov, Kud-Sverchkov) (All Channels)

July 5, Sunday
11 a.m., 6 p.m., 10 p.m. - Replay of International Space Station Expedition 63-64 Crew News Conference (Rubins, Ryzhikov, Kud-Sverchkov) (All Channels)

July 7, Tuesday
12:30 p.m. – International Space Station Expedition 63 in-flight event with the New York Times, Fox News with Bill Hemmer and USA Today and Station Commander Chris Cassidy of NASA and NASA astronauts Doug Hurley and Bob Behnken (All Channels)

Watch NASA TV on the Net by going to the NASA website.

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Space Calendar

- Jul 03 - "Pics Or It Didn't Happen" Electron Launch
- Jul 03 - Comet C/2020 F3 (NEOWISE) Perihelion (0.295 AU)
- Jul 03 - Comet 202P/Scotti At Opposition (4.111 AU)
- Jul 03 - Comet C/2017 K5 (PANSTARRS) Closest Approach To Earth (6.688 AU)
- Jul 03 - Apollo Asteroid 2020 MO Near-Earth Flyby (0.024 AU)
- Jul 03 - [Jun 27] Amor Asteroid 2020 MT2 Near-Earth Flyby (0.041 AU)
- Jul 03 - Asteroid 242516 Lindseystirling Closest Approach To Earth (1.617 AU)
- Jul 03 - Harrison Schmitt's 85th Birthday (1935)
- Jul 04 - Earth At Aphelion (1.017 AU From Sun)
- Jul 04 - Comet 206P/Barnard-Boattini At Opposition (1.946 AU)
- Jul 04 - Comet C/2017 K5 (PANSTARRS) At Opposition (6.688 AU)
- Jul 04 - Apollo Ateroid 2007 UN12 Near-Earth Flyiby (0.043 AU)
- Jul 04 - Apollo Asteroid 2020 LS Near-Earth Flyby (0.050 AU)
- Jul 04 - Asteroid 3169 Ostro Closest Approach To Earth (0.993 AU)
- Jul 04 - Asteroid 9325 Stonehenge Closest Approach To Earth (1.519 AU)
- Jul 04 - Asteroid 11998 Fermilab Closest Approach To Earth (1.644 AU)
- Jul 04 - Asteroid 204852 Frankfurt Closest Approach To Earth (1.788 AU)
- Jul 04 - Asteroid 11814 Schwamb Closest Approach To Earth (1.986 AU)
- Jul 04 - Asteroid 8889 Mockturtle Closest Approach To Earth (2.100 AU)
- Jul 04 - Asteroid 777 Gutemberga Closest Approach To Earth (2.222 AU)
- Jul 04 - 15th Anniversary (2005), Deep Impact, Comet Tempel 1 Impact/Flyby
- Jul 04 - 75th Anniversary (1945), Baby Wac Launch
- Jul 05 - [Jun 29] Penumbral Lunar Eclipse
- Jul 05 - Comet 74P/Smirnova-Chernykh At Opposition (3.383 AU)
- Jul 05 - Comet 183P/Korlevic-Juric At Opposition (3.736 AU)
- Jul 05 - Comet C/2016 Q2 (PANSTARRS) At Opposition (6.855 AU)
- Jul 05 - Apollo Asteroid 10563 Izhdubar Closest Approach To Earth (0.831 AU)
- Jul 05 - Asteroid 13606 Bean Closest Approach To Earth (1.183 AU)
- Jul 05 - Asteroid 43844 Rowling Closest Approach To Earth (1.611 AU)
- Jul 05 - Asteroid 4352 Kyoto Closest Approach To Earth (2.100 AU)
- Jul 05 - Neptune Trojan 2008 LC18 At Opposition (31.393 AU)
- Jul 05 - Kuiper Belt Object 307261 (2002 MS4) At Opposition (45.539 AU)
- Jul 05 - William Rankine's 200th Birthday (1820)
- Jul 06 - Comet 113P/Spitaler At Opposition (3.413 AU)
- Jul 06 - Comet C/2017 Y2 (PANSTARRS) At Opposition (3.959 AU)
- Jul 06 - Comet C/2017 U7 (PANSTARRS At Opposition (5.716 AU)

Source: JPL Space Calendar

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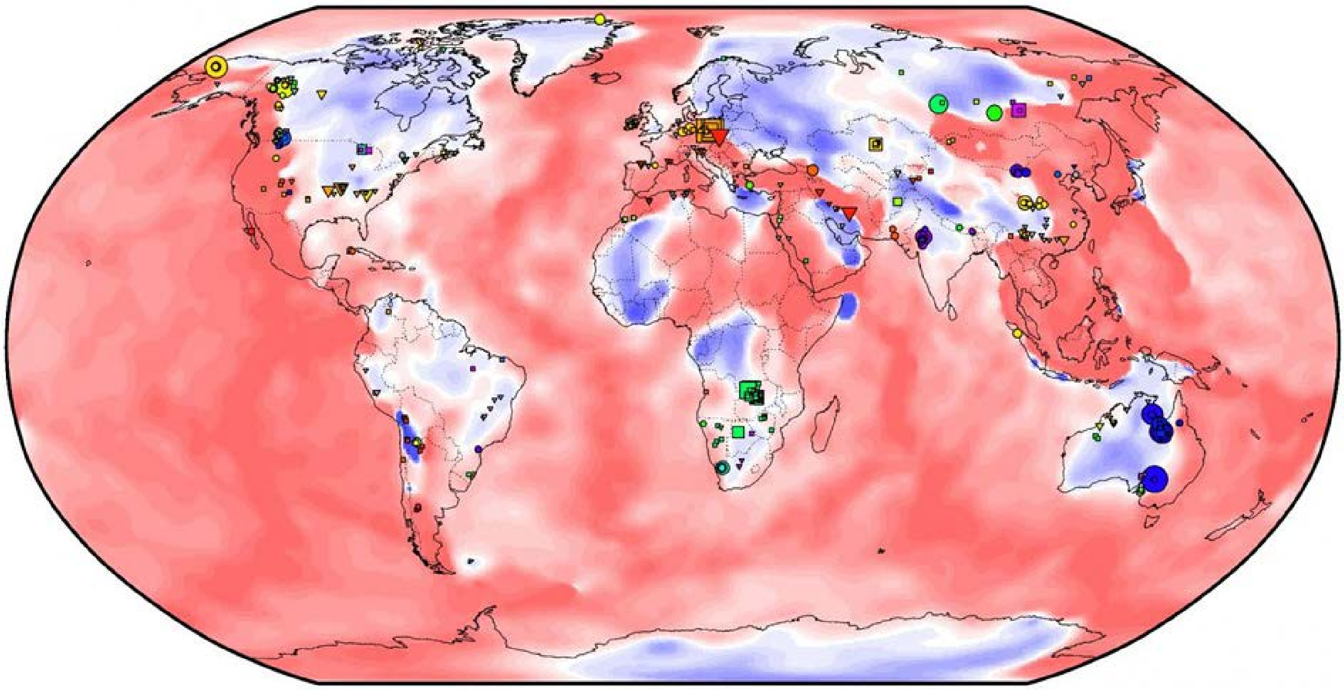
Food for Thought

Geologists Identify Deep-Earth Structures That May Signal Hidden Metal Lodes



If the world is to maintain a sustainable economy and fend off the worst effects of climate change, at least one industry will soon have to ramp up dramatically: the mining of metals needed to create a vast infrastructure for renewable power generation, storage, transmission and usage.

The problem is, demand for such metals is likely to far outstrip currently both known deposits and the existing technology used to find more ore bodies.

Now, in a new study, scientists have discovered previously unrecognized structural lines 100 miles or more down in the earth that appear to signal the locations of giant deposits of copper, lead, zinc and other vital metals lying close enough to the surface to be mined, but too far down to be found using current exploration methods. The discovery could greatly narrow down search areas, and reduce the footprint of future mines, the authors say. The study appears this week in the journal Nature Geoscience.

"We can't get away from these metals-they're in everything, and we're not going to recycle everything that was ever made," said lead author Mark Hoggard, a postdoctoral researcher at Harvard University and Columbia University's Lamont-Doherty Earth Observatory. "There's a real need for alternative sources."

The study found that 85 percent of all known base-metal deposits hosted in sediments-and 100 percent of all "giant" deposits (those holding more than 10 million tons of metal)-lie above deeply buried lines girdling the planet that mark the edges of ancient continents. Specifically, the deposits lie along boundaries where the earth's lithosphere-the rigid outermost cladding of the planet, comprising the crust and upper mantle-thins out to about 170 kilometers below the surface.

Up to now, all such deposits have been found pretty much at the surface, and their locations have seemed to be somewhat random. Most discoveries have been made basically by geologists combing the ground and whacking at rocks with hammers. Geophysical exploration methods using gravity and other parameters to find buried ore bodies have entered in recent decades, but the results have been underwhelming. The new study presents geologists with a new, high-tech treasure map telling them where to look.

Due to the demands of modern technology and the growth of populations and economies, the need for base metals in the next 25 years is projected to outpace all the base metals so far mined in human history. Copper is used in basically all electronics wiring, from cell phones to generators; lead for photovoltaic cells, high-voltage cables, batteries and super capacitors; and zinc for batteries, as well as fertilizers in regions where it is a limiting factor in soils, including much of China and India. Many base-metal mines also yield rarer needed elements, including cobalt, iridium and molybdenum. One recent study suggests that in order to develop a sustainable global economy, between 2015 and 2050 electric passenger vehicles must increase from 1.2 million to 1 billion; battery capacity from 0.5 gigawatt hours to 12,000; and photovoltaic capacity from 223 gigawatts to more than 7,000.

The new study started in 2016 in Australia, where much of the world's lead, zinc and copper is mined. The government funded work to see whether mines in the northern part of the continent had anything in common. It built on the fact that in recent years, scientists around the world have been using seismic waves to map the highly variable depth of the lithosphere, which ranges down to 300 kilometers in the nuclei of the most ancient, undisturbed continental masses, and tapers to near zero under the younger rocks of the ocean floors. As continents have shifted, collided and rifted over many eons, their subsurfaces have developed scar-like lithospheric irregularities, many of which have now been mapped.

The study's authors found that the richest Australian mines lay neatly along the line where thick, old lithosphere grades out to 170 kilometers as it approaches the coast. They then expanded their investigation to some 2,100 sediment-hosted mines across the world, and found an identical pattern. Some of the 170-kilometer boundaries lie near current coastlines, but many are nestled deep within the continents, having formed at various points in the distant past when the continents had different shapes. Some are up to 2 billion years old.

The scientists' map shows such zones looping through all the continents, including areas in western Canada; the coasts of Australia, Greenland and Antarctica; the western, southeastern and Great Lakes regions of the United States; and much of the Amazon, northwest and southern Africa, northern India and central Asia. While some of the identified areas already host enormous mines, others are complete blanks on the mining map.

The authors believe that the metal deposits formed when thick continental rocks stretched out and sagged to form a depression, like a wad of gum pulled apart. This thinned the lithosphere and allowed seawater to flood in. Over long periods, these watery low spots got filled in with metal-bearing sediments from adjoining, higher-elevation rocks. Salty water then circulated downward until reaching depths where chemical and temperature conditions were just right for metals picked up by the water in deep parts of the basin to precipitate out to form giant deposits, anywhere from 100 meters to 10 kilometers below the then-surface. The key ingredient was the depth of the lithosphere. Where it is thickest, little heat from the hot lower mantle rises to potential near-surface ore-forming zones, and where it is thinnest, a lot of heat gets through. The 170-kilometer boundary seems to be Goldilocks zone for creating just the right temperature conditions, as long as the right chemistry also is present.

"It really just hits the sweet spot," said Hoggard. "These deposits contain lots of metal bound up in high-grade ores, so once you find something like this, you only have to dig one hole." Most current base-metal mines are sprawling, destructive open-pit operations. But in many cases, deposits starting as far down as a kilometer could probably be mined economically, and these would "almost certainly be taken out via much less disruptive shafts," said Hoggard.

The study promises to open exploration in so far poorly explored areas, including parts of Australia, central Asia and western Africa. Based on a preliminary report of the new study that the authors presented at an academic conference last year, a few companies appear to have already claimed ground in Australia and North America. But the mining industry is notoriously secretive, so it is not clear yet how widespread such activity might be.

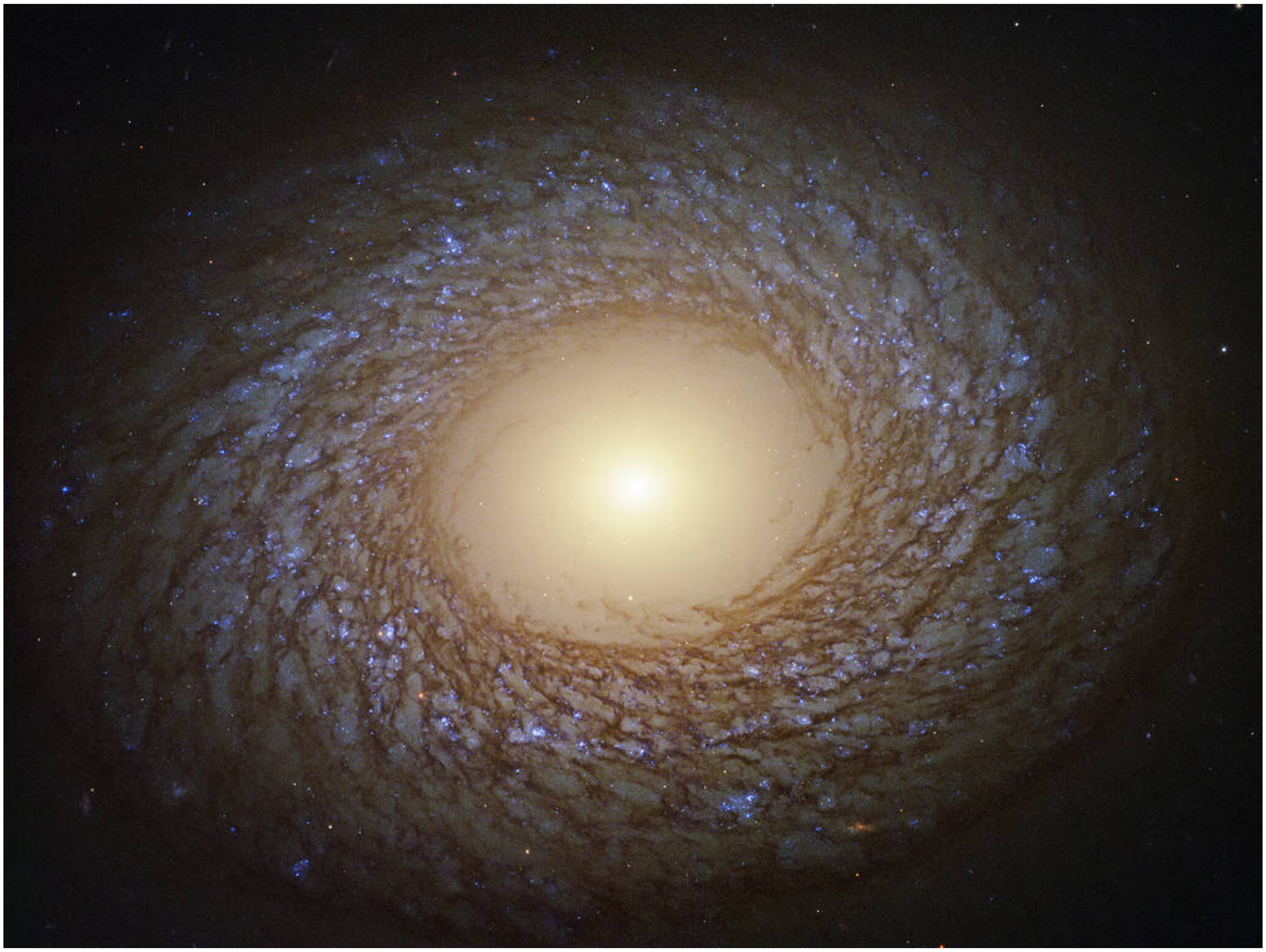
"This is a truly profound finding and is the first time anyone has suggested that mineral deposits formed in sedimentary basins ... at depths of only kilometers in the crust were being controlled by forces at depths of hundreds of kilometers at the base of the lithosphere," said a report in Mining Journal reviewing the preliminary presentation last year.

The study's other authors are Karol Czarnota of Geoscience Australia, who led the initial Australian mapping project; Fred Richards of Harvard University and Imperial College London; David Huston of Geoscience Australia; and A. Lynton Jaques and Sia Ghelichkhan of Australian National University.

Hoggard has put the study into a global context on his website: https://mjhoggard.com/2020/06/29/treasure-maps

Source: Spaceref.com Return to Contents

Space Image of the Week



Hubble Spots Feathered Spiral

Explanation The spiral pattern shown by the galaxy in this image from the NASA/ESA Hubble Space Telescope is striking because of its delicate, feathery nature. These "flocculent" spiral arms indicate that the recent history of star formation of the galaxy, known as NGC 2775, has been relatively quiet. There is virtually no star formation in the central part of the galaxy, which is dominated by an unusually large and relatively empty galactic bulge, where all the gas was converted into stars long ago.

NGC 2275 is classified as a flocculent (or fluffy-looking) spiral galaxy, located 67 million light-years away in the constellation of Cancer.

Millions of bright, young, blue stars shine in the complex, feather-like spiral arms, interlaced with dark lanes of dust. Complexes of these hot, blue stars are thought to trigger star formation in nearby gas clouds. The overall feather-like spiral patterns of the arms are then formed by shearing of the gas clouds as the galaxy rotates. The spiral nature of flocculent galaxies stands in contrast to the grand-design spirals, which have prominent, well defined-spiral arms.

Text credit: ESA (European Space Agency)
Image credit: ESA/Hubble & NASA, J. Lee and the PHANGS-HST Team; Acknowledgment: Judy Schmidt (Geckzilla)

Source: NASA Return to Contents