

A whole new moon

Lava tubes. Cave cities. Extreme sports. The next century of lunar settlement is wilder than you think.

by [Chris Taylor](#)

*NOTE FOR 2019 READERS: This is the eighth in a [series of open letters to the next century](#). The series marks a little-known chronological milestone. According to [UN data](#), life expectancy at birth in 27 countries now exceeds 81 years — so babies born in 2019 are more likely than not to be alive in 2100. What will life be like at the other end of these kids' lives?*

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Dear July 20, 2119,

From the 50th to the 150th anniversary of the Apollo 11 moon landing, greetings!

No doubt you'll be marking this moment just as we are — by watching that hallowed, grainy footage from 1969. We can share a knowing smile at the outdated fashions and habits. (All those white men wearing ties and smoking cigarettes at mission control!) Our hearts will race all over again when NASA loses contact with the three astronauts during orbital maneuvers, or when the late, legendary Neil Armstrong avoids a disastrous crash landing by the Sea of Tranquility with only seconds left on the fuel clock.

But what would we really have to say to each other, after watching this footage together? Not a whole lot, if we're honest. Making conversation, you might ask: So, when was the last time you visited the moon? And we would have to admit, shame-facedly, that none of us have. That only 12 members of our parents' and grandparents' generation (again, all white men) ever touched the lunar surface, and only 4 of them are still alive as I write this. But [we're planning to go again real soon, honest](#).

And in that moment, we would be revealed as the worst kind of rubes — the cosmic equivalent of tourists who visit Paris once, spend three nights there (80 hours is the paltry total amount of time Apollo missions spent on the moon), then won't shut up about it for the next five decades. We keep dragging out the photo album, reminiscing about how happy we were and how important it all seemed, and how we really must go back some day, when we're less busy.

In a few years, maybe, when NASA has finished [testing the necessary rocket](#), or when one of our billionaires finally fulfills his promise to start a [space tourism](#) business.



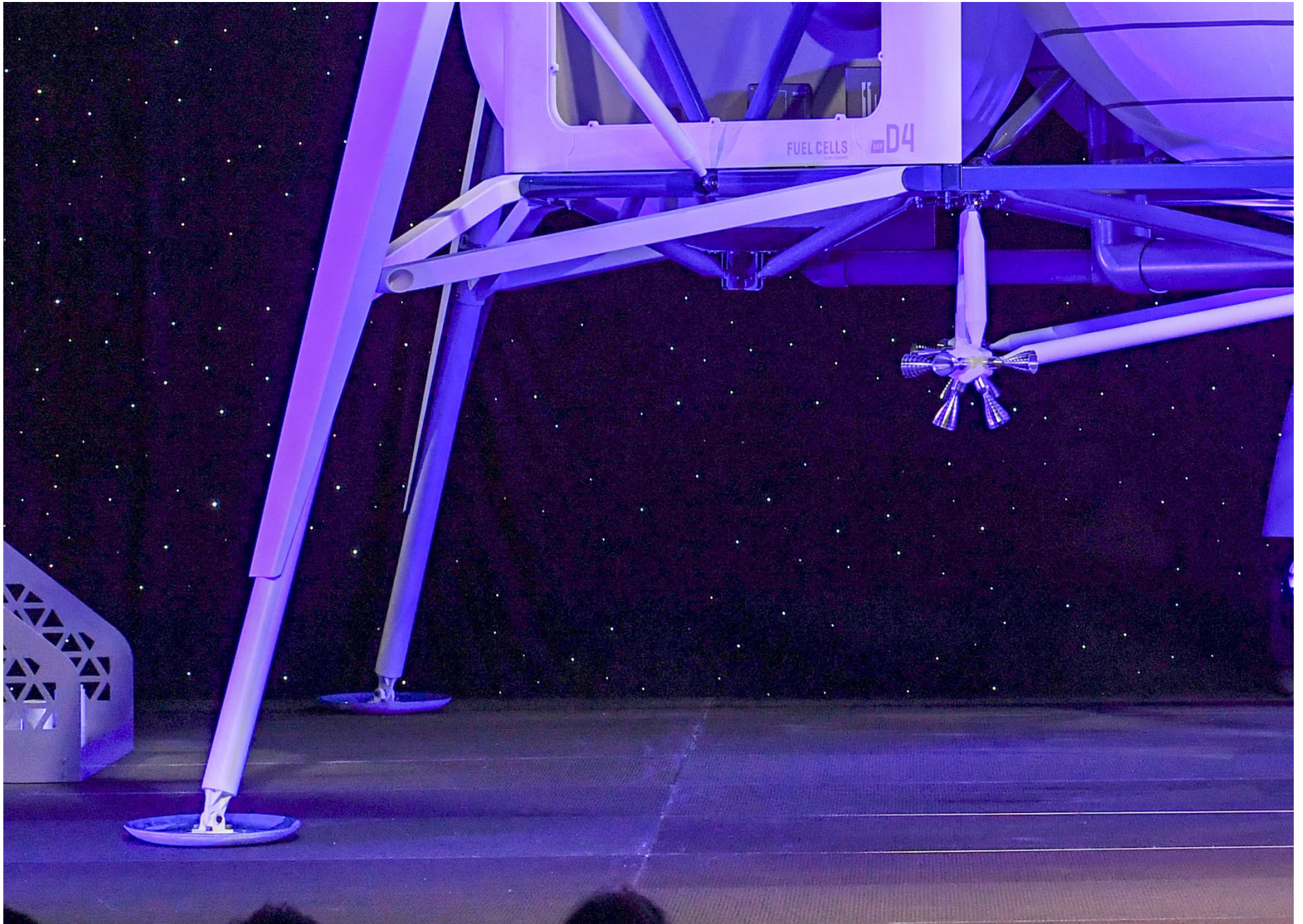
For you future sophisticates, however, I have no doubt that going to the moon — probably via a couple of [space elevators](#) and a transfer shuttle between them — is almost boringly basic, just as the people of 1969 suspected it would be. It's the sort of thing you might do for birthdays or honeymoons. Thousands live there permanently, mostly underground in the vast, city-sized lava tubes we've only just discovered; hundreds of thousands have visited for a week or more.

There's a booming lunar economy. The pioneer generation of helium-3 mining roughnecks and lava tube construction crews has been supplanted by manufacturers, biochemists, pharmaceutical company executives, plus semiconductor and solar-panel salespeople (the near-vacuum and low-gravity environment of the moon would be great for all those businesses). Since one suggestion for dealing with [pesky, potentially lethal lunar dust](#) is literally to melt the moon's surface (with solar power or [lasers](#)) into slippery glass, I expect insurance claims adjusters will be a growing profession, too.

Oh, and sports fans will flock there, of course. Because you haven't lived until you've watched ballers breaking records on the moon.







You saw him standing alone: Blue Origin and Amazon CEO Jeff Bezos unveils a lander he'll supposedly send to the moon in 2024.

Jonathan Newton / The Washington Post via Getty Images



Why am I so certain that this is your reality, and that you aren't also airily dreaming of someday on the moon? Because there are massive historical and economic forces building up pressure that will push us in a lunar direction over the next century. The release of that pressure is inevitable, no matter how long we procrastinate. In the 2020s, after so many false starts, the moon is booked for a whole bunch of visitors, both governmental and commercial.

Even if their arrival slips by a decade or two, we're looking at more than 70 years of perpetual human presence by your time.

The first force is the same one that propelled Apollo: national pride. But not just American national pride this time, although NASA's promise to send another man and the first woman to the moon in 2024 (via Orion rocket and the [Lunar Gateway](#), a proposed space station in lunar orbit) is certainly the most ambitious plan currently on the books. And not just Russian pride, although the formerly Soviet moon program is about to resume. Having left off with the soil-gathering robot Luna 24 in 1976, Roscosmos aims to pick right up with the [Luna 25 lander in 2021](#) (which may test robotic drilling on the moon for the first time) and the Luna 26 orbiter in 2023. Lunas 27 and 28 will join them at the crucial south pole region, [where the ice is](#), in 2025 or beyond.

The days when the moon was the exclusive preserve of two superpowers already seem quaint. China cemented its position as the third great lunar power last December, when Chang'e 4 became the [first spacecraft to land on the far side of the moon](#), and the Queqiao relay satellite was waiting to keep it in constant contact with Earth.

Next up are the Chang'e 5 and 6 sample return missions in December 2019 and 2023, respectively. One successful Chang'e 4 experiment involved sprouting a cotton seed, the first plant to germinate on the moon — [for a while](#), at least.





Planting on the moon: Student volunteers at China's Lunar Palace 1 set a record for the longest stay in a self-contained cabin.

Xinhua/Luo Xiangguang via Getty Images

China can also brag about Lunar Palace 1, an ongoing on-Earth experiment where male and female volunteers live for months at a time with recycled food and water. Last year they completed a record-breaking, [year-long mock-mission to the moon](#). The country is planning to build it on the moon for real, in pieces, [supposedly by 2025](#).



Having won the first moon race in 1969, the U.S. could pretty much lose the moon altogether to the pace of Chinese ingenuity. One of our top science fiction authors, Kim Stanley Robinson (whom you met in [this letter](#)) just published the novel [Red Moon](#), in which Chinese infrastructure and culture dominates our nearest celestial neighbor by 2047. “They’ve taken over the south pole, and all the other nations are clustered around the north pole,” Robinson explains.

And here comes India, set to catch up to China not just in population but also in lunar exploration. The Chandrayaan-2 mission, supposed to launch this month, was delayed by a technical glitch. (Another infernal delay!) When it finally takes flight, Chandrayaan-2 will deliver the Vikram lander and Pragyaam robot rover to the increasingly crowded south pole.

The European Space Agency has announced plans for a multinational “moon village,” with 3D printed habitats that look a lot like [Luke Skywalker’s Tatooine hovel](#), while South Korea and Japan are both dipping their toes in the lunar seas. Korea has an orbiter slated for launch in 2020, while Japan’s delightfully-named Smart Lander for Investigating Moon (SLIM) aims to investigate one of those newly-discovered lava tubes in 2022.

National governments are no longer the only owners of moon-based objects. The 8-year-old Israeli startup SpaceIL was the first private company to launch a lander, the Beresheet, back in April. Sure, it crash-landed, but it’s still there, along with a [pretty-much indestructible library containing nearly all human knowledge](#). You future moon tourists will never be without something to read, so long as you can locate it. You’re welcome.



The Google Lunar X Prize (which offered \$30 million for the first team to land a robot on the moon) [folded in 2018](#), after none of the five competing companies launched in time. But SpaceIL’s launch was proof that the teams weren’t just spouting hot air.

Other rivals are also still in the race: [TeamIndus](#) and [Space Mission](#) have teamed up to launch their robot rovers in the 2020s, while Moon Express has won a NASA lunar payload contract to deliver scientific instruments and other vital infrastructure. As have other startups that weren’t even around when the X Prize began: [OrbitBeyond](#) (planned launching September 2020), Astrobotic (Perseus lander, [launching June 2021](#)) and Intuitive Machines (Nova C Lander, [launching July 2021](#)).

Of course, these efforts may or may not succeed. Will some or most of these companies fail? They very likely will, as NASA administrator Jim Bridenstine admitted the day he announced the contract. “But the return on investment when one of them succeeds is huge,” Bridenstine told me, [while simultaneously navigating a lunar lander simulator to a soft landing at a virtual lunar moonbase](#).

Which moon-bound companies will succeed. Maybe one or two of them are household names in your era. I’m willing to bet you know the name Jeff Bezos; the wealthiest man on our world unveiled his people-ready Blue Moon lander, made by his company Blue Origin, in May 2019. Like the NASA Artemis mission, [Blue Moon is slated to arrive at the south pole sometime in 2024](#).

Should be quite a party down there; hopefully someone remembers to bring the beer.







New moon competitors: Kailasavaidoo Sivan (R), chairman of the Indian Space Research Organization, outlines India's plan for a crewed mission to the moon by 2021, while NASA's Jim Bridenstine discusses the U.S. plan to return by 2024.

MANJUNATH KIRAN/AFP/Getty Images and NASA/Aubrey Gemignani

Bezos' billionaire rival in the immortality stakes, Elon Musk, is less precise about his SpaceX moon landing plans. He wants to build a permanently-occupied base "as fast as possible," via his imaginatively-named Starship. What Musk has announced is a plan to take the first true non-orbital space tourist on a trip around the moon in 2023 in the BFR (Big Falcon Rocket); Yusaku Maezawa, CEO of fashion retailer Zozo.

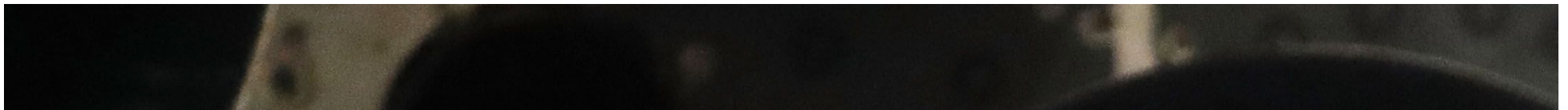
Now, Zozo is losing money, and Maezawa [recently had to auction off some of his paintings](#), so who knows if he'll reclaim his deposit and cancel the trip. But he has the right idea, at least: send more creatives to the moon to help inspire the rest of us. "If Pablo Picasso had been able to see the moon up close, what kind of paintings would he have drawn?" Maezawa told veteran space journalist Leonard David in [Moon Rush](#). "If John Lennon could have seen the curvature of the Earth, what kind of songs would he have written?"

He has a point: The Apollo mission [basically brought us David Bowie](#), and he never even left the planet.

So yes, we need to send artists to the moon, but we also need to send a hell of a lot more scientists. Because our lunar knowledge is still embarrassingly slim. The Apollo astronauts, all those robotic landers — they barely scratched the surface, literally and figuratively, of our still-mysterious satellite. We know there's ice at the poles, but we don't know how much or how mixed in with the dirt it is.

We know there's a lot of helium-3, a rare isotope that could be used to power fusion reactors, and could be worth around \$1 million per ounce on the secondary market, according to David. In theory, there's enough helium-3 on the moon to [power Earth's energy needs for 10,000 years](#). Which — along with the concept of vast lunar solar panels in a place with no atmosphere to hamper energy collection, beaming it back to Earth — should make a moon mission a big part of any Green New Deal. (One Japanese construction company has already sketched out plans for [a ring of solar panels around the moon's equator](#).)

Then again, the helium-3 is all clustered on the crust, and might require "a strip-mining operation so vast that you can see it from Earth," says professor Timothy Swindle, head of the Lunar & Planetary Laboratory at the University of Arizona. In which case, he adds, "you'd be better off mining the atmospheres of Saturn or Uranus," where helium-3 is more abundant.











SpaceX founder Elon Musk and Yusaka Maezawa, the Japanese billionaire who plans to become the first lunar space tourist in 2023.

Mario Tama / Getty Images

We think there are lots of rare Earth minerals up for grabs, near the surface of the moon. Which would be great, as China currently has around 80 percent of the world's supply, much of modern technology relies on them, and the current trade war is [sending prices skyrocketing](#). (That's a major economic force driving us to the moon in the long run, just as Columbus went west to find a new non-monopolized route for Indian spices.)

We think there's a ton of titanium, iron, silicon, aluminum, magnesium, and other materials that make manufacturers lick their lips. We think. Oh, and as of this year, we think there's some kind of [mysterious mass of dense metal](#), five times larger than the Big Island of Hawaii, lurking underneath the lunar South Pole, probably from some ancient asteroid impact.

Which metal? You know. We're all like  $\neg(\prime)\_/\_$ .

Not knowing for sure what lies beneath the dusty gray surface is hampering our best-laid plans, and making the shape of the decades between us and you unclear. "There are lots of hand-wavy ideas, but we need data we can only get from the surface," says Clive Neal, planetary scientist and former chairman of the [Lunar Exploration Analysis Group](#), a NASA advisory board. "We can't do any real planning until we find what resources are there."

Take those lava tubes you guys may be living in. [We only just discovered them in 2017](#). We know they're perfect for habitation, protecting us from cosmic radiation and micrometeorites and solar flares and that hazardous surface dust. But how many are there? How deep do they go? Is the moon riddled with them, looking a lot like Swiss cheese after all?

Could there really be, as the 2017 study theorized, a lava cave near Marius Hills [so large that you could fit the city of Philadelphia in it](#)?

If so, that opens up whole new vistas of moon habitation. Our celestial neighbor could support millions, not just thousands of people. Lava tubes could lead eventually to some kind of public transit system: Forget the London Underground, visit the *Lunar* Underground!

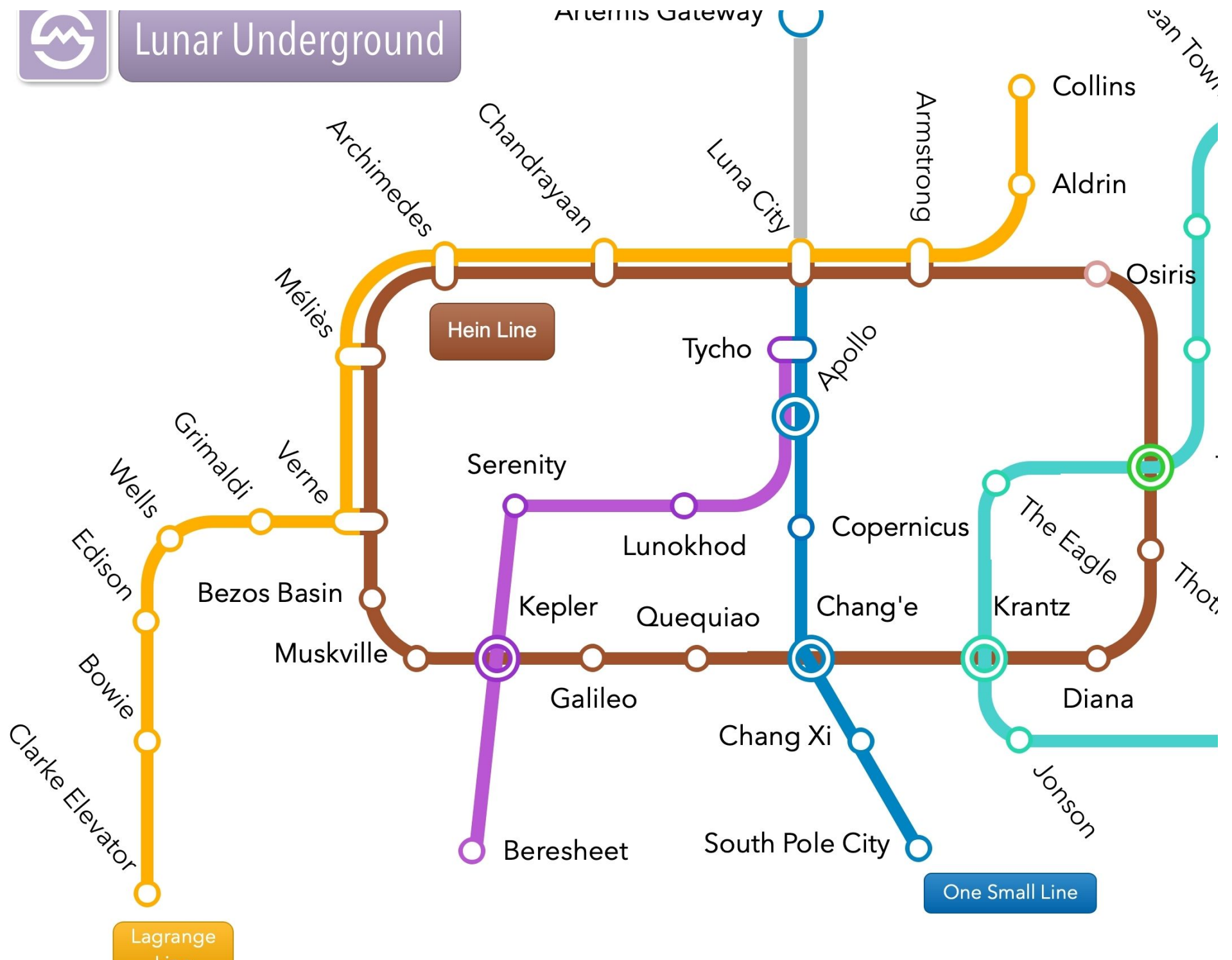
The volcanic activity that formed these tubes has long since gone, but the cave structures they left in their wake could house a whole civilization that looks decidedly Jules Verne-esque — less [From the Earth to the Moon](#), more [Journey to the Center of the Earth](#).







# Lunar Underground





Tomorrow's transit? What a Lunar Underground system in the moon's lava tubes might look like.

Chris Taylor

Of course, living in a cave would be drab at the best of times, even with the best of internal lighting. Which is why it's a good thing you're likely to have plenty of opportunities to get out and about on the surface.

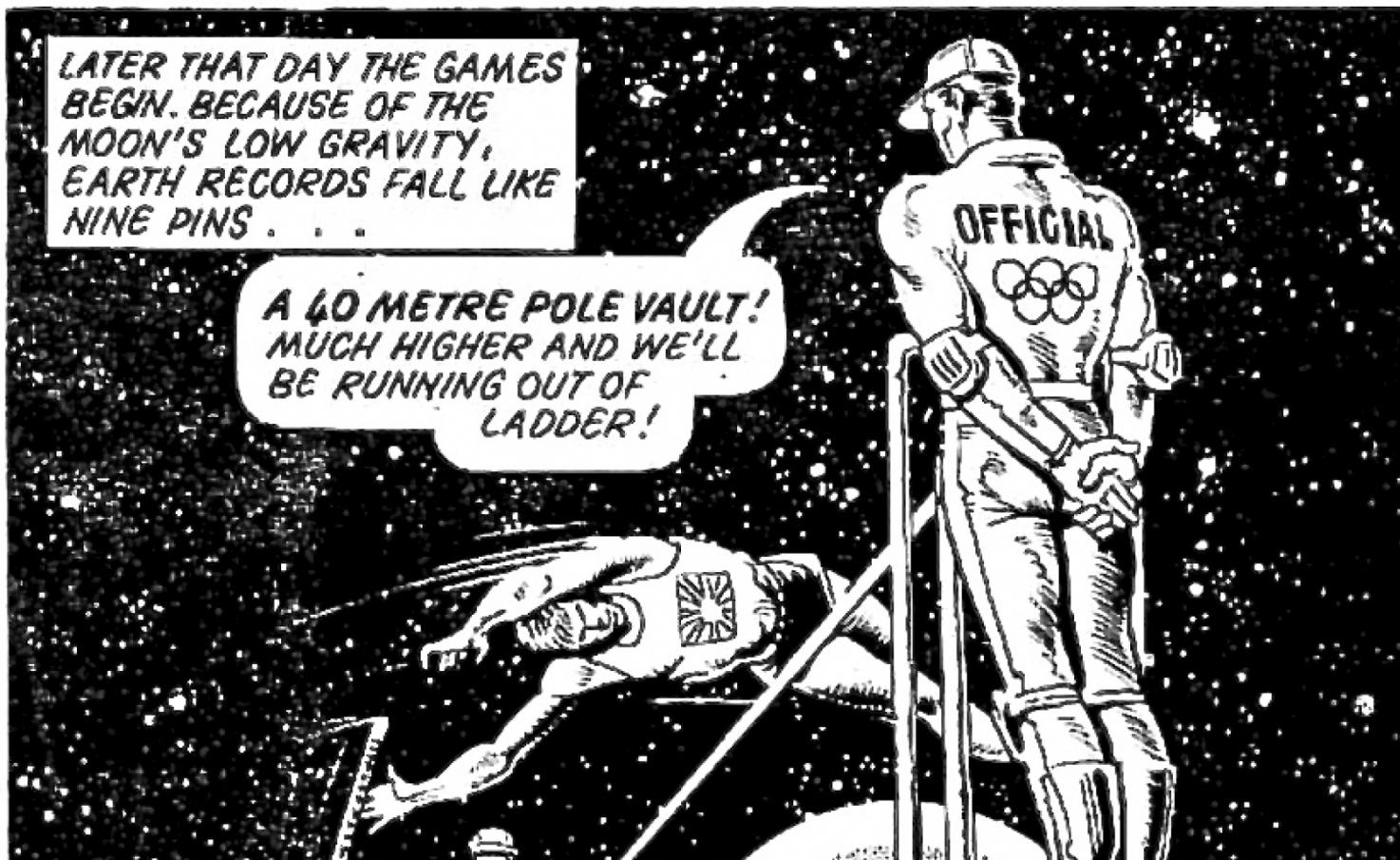
If we build a lunar space elevator to get equipment to and from Earth — which could do with a space elevator of its own, by the way — then physics requires it to be connected to a point somewhere on the equator ([probably at the Sinus Medii sea](#)). How to connect that to the base we're likely to build at the south pole, the farthest possible distance away? A tramline longer than any on Earth is one idea that has been mooted, or possibly a low-gravity lunar hopper. You have options, and the views are spectacular!

Speaking of spectacular, speaking of getting out and about, speaking of inevitable forces, two words: lunar sports. The potential is enormous, and it has already been demonstrated. Like the basic tourists they were, the Apollo astronauts began with golf. Alan Shepard famously brought a 6-iron and a couple of balls aboard Apollo 14.

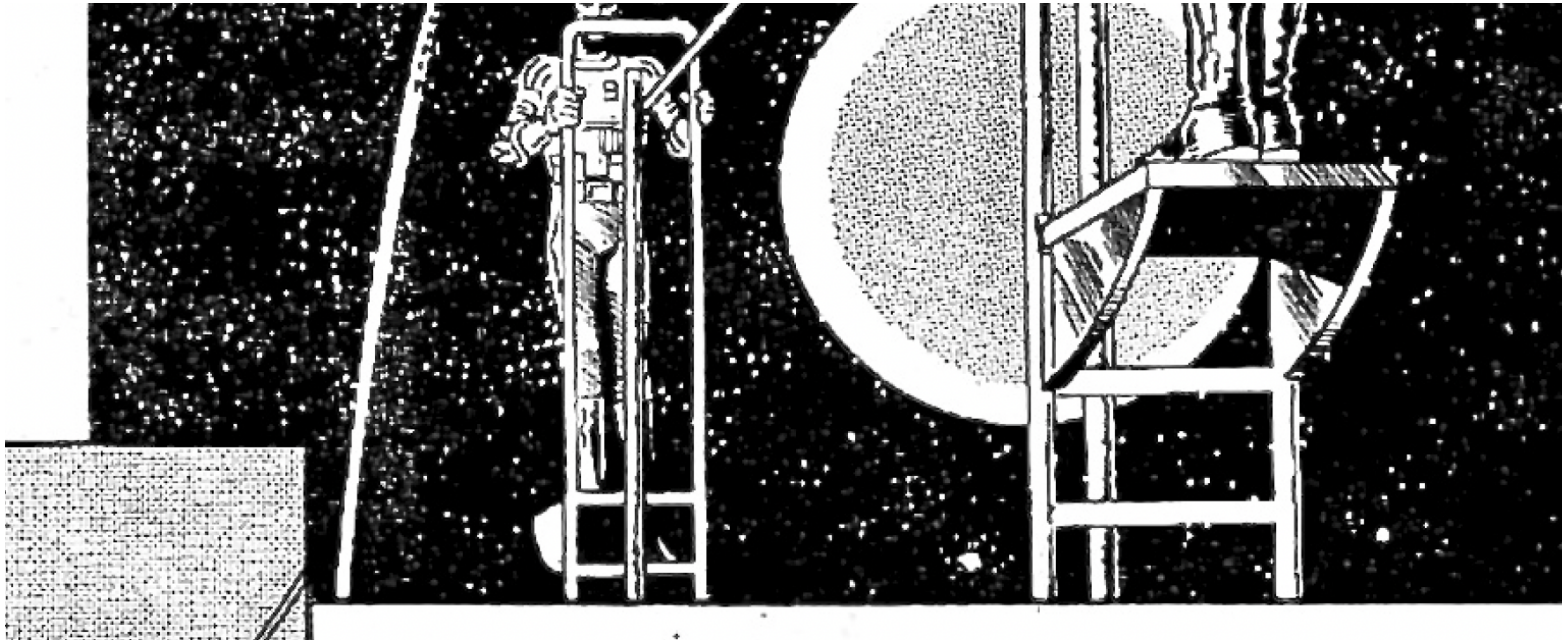


His first shot went over a mile, instantly shattering all Earthbound golf records. Not to be outdone, his lunar buddy Edgar Mitchell created a makeshift javelin out of an excavation tool, which he says went even further than Shepard's shot.

The moon's gravity, as you well know, is a mere 17 percent of Earth's, and that would make just about any sport essential viewing — especially in a clean, well-lit, oxygen-filled, super-tough ball-proof glass stadium dome, above or below ground. We can already imagine that some sports would thrive more than others. Baseball would probably get boring when every shot is a homer, but the dunking in basketball would be insane. Soccer would turn into beautiful slow-motion ballet, with aerial bicycle kicks from the strikers and giant saving leaps from the goalies.







A panel from the 1978 'Judge Dredd' comic strip about the Lunar Olympics -- set in the 22nd century.

2000AD

But the best sport streaming on Lunar Pay-Per-View (a multibillion-dollar business, no doubt) is probably one we haven't invented yet. Perhaps it bears some similarity to [Quidditch](#), minus the need for magical broomsticks. Or perhaps it's something so complex that our puny 21st century minds can't begin to comprehend the scoring system.

Lunar rubes like us will be happy just to afford the ticket.

*Yours in ancestral anticipation,*

*July 20, 2019*

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Chris Taylor
- Edited by  
Brittany Levine Beckman
- Top illustration by  
Bob Al-Greene