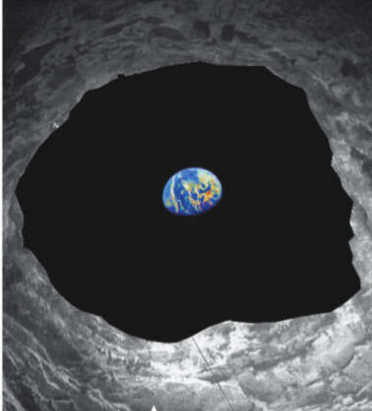




Science is simply common sense at its best, that is, rigidly accurate in observation, and merciless to fallacy in logic. - Thomas Huxley



Underground cave system on the Moon discovered by NASA's Lunar Reconnaissance Orbiter (LRO) | NASA

HRITHIK KIRAN BAGADE

HEN Neil Armstrong first stepped on the Moon, from Apollo 11's lunar module, on July 20, 1969, his iconic words - "That's one small step for a man, one giant leap for mankind" - were more than a catchphrase for posterity. They reflected the futuristic fascination that drew the human species to the Moon and beyond, for the purpose of adventure, science, exploration, and at present hypothetically-speaking, 'colonisation'.

The Moon, being the Earth's nearest celestial object, has particularly evoked immense interest for its sheer majesty, and also as a gateway to further future cosmic odysseys. Accordingly, astrophysicists and the pundits of sci-fi have charted a theoretical roadmap for colonisation of the Moon. The idea is that in the future, humans may live and work on the moon for weeks or even months. It is a process or concept employed by some propo-

sals for robotic or human exploitation and settlement endeavours on Earth's natural satellite. Energy and power will make it possible to travel to and live on the lunar surface. Humans must choose the appropriate energy source and technological means to produce that power. Solar energy is abundant on the moon, and ways must be found to effectively harness it.

While a range of proposals for missions of lunar colonisation, exploitation or permanent exploration have been raised, current projects for establishing a permanent crewed presence on the Moon are not for colonisation, but to focus on building moonbases for exploration and to a lesser extent for harnessing lunar resources. In reality, currently global space agencies, including India's ISRO, are looking at studying specific regions of the lunar surface, so as to understand the scientific potential that the Moon may unlock, as we dive deeper into space.

When we talk about looking at a suitable perennial energy resource to run extended lunar missions, in the form of crevassed stations, one must also take into account the topography and environment of the Moon. The Moon is not one smooth white/grey ball of rock. It's surface is composed of Anorthosite, which is a calcium-rich white rock, although not as bright as the light-colored feldspars, a common, light-weight, light-colored mineral on Earth. It is an igneous rock, which means it cooled and solidified from hot molten material. Also, the Moon's environment is not nearly as easy to live in as Earth's. Apart from the toxic lunar dust, the sparse atmosphere provides no protection from meteorites or radiation. The temperature fluctuations on the Moon are also intense, ranging from -248 to 127 degrees Celsius. This again leads to the question

of how can the Moon be made more survivable, begging the need for shelters. In addition to protecting inhabitants from meteorites, radiation and toxic lunar dust, a sealed shelter would allow them to breathe. While the primary purpose of moonbases is mostly for space exploration, exploiting and commercialising the Moon, it also theoretically advocates for a lunar and cis-lunar infrastructure, economy and settled society. Hence, conditions ought to be appropriated.

Discovery of a cave

In this direction, just this week, a team of international scientists, under the lead of the University of Trento, Italy, have made a breakthrough. They published a paper in Nature Astronomy demonstrating the existence of a tunnel in the lunar subsurface. It seems to be an empty lava tube, which could pave the way for human habitation on the Moon. "These caves have been theorised for over 50 years, but it is the first time ever that we have demonstrated their existence", explains Lorenzo Bruzzone, professor at the University of Trento.

How was this demonstration achieved? Bruzzone explains: "In 2010, as part of the ongoing LRO NASA mission, the Miniature Radio-Frequency (Mini-RF) instrument acquired data that included a pit in Mare Tranquillitatis. Years later we have reanalysed this data with complex signal processing techniques we have recently developed, and have discovered radar reflections from the area of the pit that are best explained by an underground cave conduit. This discovery provides the first direct evidence of an accessible lava tube under the surface of the Moon."

"Thanks to the analysis of the data we were able to create a model of a portion of the conduit," continues Leonardo Carer, re-



Apollo 11's Buzz Aldrin with the US flag on the Moon | NASA

searcher at University of Trento. This study has scientific implications for the development of missions to the Moon, where the environment is hostile to human life. The aforesaid conditions drive the need to find safe sites for the construction of infrastructure that can support sustained exploration. Caves such as this one offer a solution to that problem, the scientists conclude.

Breathing on the Moon is out of question. The Moon technically does have an atmosphere, but the gases are so spread out that they do not support breathing. Experiments on the International Space Station have shown how recycling air systems could be adapted for the Moon. This could look like planting oxygen-emitting plants in lunar greenhouses, and then sending the purified air through sealed habitations pods. This would be an entirely new way of life that humans would need to adapt to. Also, producing and storing food to survive long periods in an alien world is key.

How can food be cultivated 384,400 km from our planet, at a place lacking requisite air, soil, or water? Lunar soil does not contain reactive nitrogen, a mineral that is necessary for plant growth. In a 2019 study, researchers were able to harvest tomatoes, peas,

radishes, cress, and ryegrass from simulated lunar soil. Also, greenhouses can simulate Earth-like soil conditions. The said research is able to depict a plausible way how fresh food can be harvested on the lunar surface. Another issue is about watering the crops. While the discovery of detectable molecular water on the near side of the Moon in October 2020 suggests that water may be more widespread, and not limited to the far side and colder regions, it is still to be seen how easily it can be accessed. If this lunar water is clean and easily attainable, it would be much quicker and economical than shuttling water from Earth. In addition, NASA is currently able to grow food on the space station. This promising development could be replicated in other microgravity environments, such as the Moon.

First lunar station

The future is now. NASA and its partners are already developing the foundational systems needed for long-term exploration of the Moon, with the Artemis campaign. "Following the Artemis III mission that will land the first people near the Moon's South Pole, astronauts on Artemis IV will live and work in humanity's first lunar space station, Gateway, which will enable new opportunities for science and preparation for human missions to Mars. The mission will bring together an intricate choreography of multiple launches and spacecraft dockings in lunar orbit, and will feature the debut of NASA's larger, more powerful version of its SLS (Space Launch System) rocket and new mobile launcher," says NASA.

The Moon is even closer to the Earth today than it actually is. It is technically possible to live on the Moon, say scientists, but many small steps for science and sustainability are needed, before that giant leap.

Living on Luna

Caves have been found under the Moon's surface, indicating a probable shelter for future researchers, while NASA is already planning a 'Gateway'. Today, human lunar habitation is not just theory, but a serious area for scientific study

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SOUTH WESTERN RAILWAY Tender Notice No. 16/2024 dated 12/07/2024. The undersigned, on behalf of the President of India, invites E-Tender through IREPS only for supply of following items:

Table with 4 columns: Sl. No., Tender No., Description in Brief, Qty., Tender Due on. Includes items like Osmierinib 80MG TAB, Recombinant Human DNA Origin Monoclonal, etc.

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Table with 5 columns: SR No., Name of the Borrower(s) / Guarantor, Description of Secured Asset (Immovable Property), Demand Notice Date and Amount, Symbolic possession takes date. Includes details for SURESH BETAGERI, etc.

DOCUMENTS LOST. I, Smt. Rathamma W/o B.Srinivasulu, Age 48, H.No. 35, W.No. 16, Sirampura Colony, Ballari. It's notified information that original Documents which received B.Srinivasulu S/o Pedda Eranna by DC office bearing No. A/Div/Rev/0380/LND/7071 have been lost on 13.07.2024 at 3:00 PM while going at Near Anjaneyya Temple, Mudraya Village. Complaint has given. If anybody found please Contact Near Police Station or 9668064980

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Public Notice. Notice is hereby given to all users of Railway lines and premises situated on the completed section of the under noted section of the Indian Railway that the 25,000 Volt 50 Hz AC Overhead Traction wires will be energized on or after the date specified against the section. On and from the same date the Overhead Traction line shall be treated as 'LIVE' at all times and no unauthorized person shall approach or work in the proximity of the said overhead line.

Table with 3 columns: Section, Date, Zone. Includes details for EMD SHED (Rd.3 to RD 11) at Hubballi, 18.07.2024, South Western Railway.

रैल विकास निगम लिमिटेड (भारत सरकार का उपक्रम) Rail Vikas Nigam Limited (A Government of India Enterprise) Proforma 10 - 01 INDIAN RAILWAYS PUBLIC NOTIFICATION

Proforma 10 - 02 INDIAN RAILWAYS INTRODUCTION OF 25 KV AC TRACTION "WARNING TO ROAD USERS"

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Table with 3 columns: Section, Date, Zone. Includes details for EMD SHED (Rd.3 to RD 11) at Hubballi, 18.07.2024, South Western Railway.