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3. Chandrayaan-2 Detects Possible Ice at Moon's South Pole – Science & Technology

Nearly six years after its launch, Chandrayaan-2 has provided new evidence suggesting the possible presence of subsurface ice in the Moon's south polar regions. Scientists used the orbiter's DFSAR (Dual Frequency Synthetic Aperture Radar) payload for advanced radar polarimetric analysis, identifying potential ice-rich subsurface material in doubly shadowed craters. Although Vikram lander did not achieve soft landing in 2019, Chandrayaan-2 Orbiter continues delivering valuable scientific data through high-resolution fully polarimetric L-band and S-band radar observations. Discovery is significant for In-Situ Resource Utilization (ISRU), future lunar exploration, and deep-space mission propellant production.

1. The Science Behind the Discovery

Doubly Shadowed Craters

1. Small craters located within larger Permanently Shadowed Regions (PSRs) near lunar poles
2. Receive neither direct sunlight nor significant scattered radiation
3. Remain among coldest known locations on Moon
4. Ideal long-term preservation sites for water-ice

Thermal Shielding

1. Regions remain extremely cold due to continuous shielding from sunlight, thermal radiation
2. Favorable conditions for long-term water-ice preservation
3. Temperatures among lowest in Solar System (~-230°C)

Volatile Trap

1. Ultra-cold regions acting as cold traps
2. Water, other volatile compounds remain preserved over geological timescales
3. Similar to natural freezers preserving ancient material

2. Analytical Methodology

Radar Polarimetric Analysis

1. Scientists used advanced radar polarimetric analysis distinguishing possible ice-rich subsurface material from rough, rocky terrain
2. Both can produce similar radar echoes requiring refined criteria

Degree of Polarization (DOP)

1. Measures how much returned radar signal retains original polarization after interacting with lunar surface/subsurface
2. Lower DOP may indicate more complex internal scattering (suggestive of ice)

Radar Detection Criterion

1. Study proposed refined diagnostic criterion for volumetric scattering -
    1. **Circular Polarization Ratio (CPR) > 1.0 AND Degree of Polarization (DOP) < 0.13**
    2. CPR alone insufficient (both rough terrain and ice produce high CPR)
    3. Combining CPR with DOP improves interpretation accuracy

Morphological Support

1. ~1.1 km-wide crater within Faustini crater showed -

    1. Enhanced radar polarization
    2. Distinct lobate-rim morphology (flow-like, tongue-shaped crater rim)
2. Suggesting impact may have excavated, interacted with ice-rich subsurface layer

3. Key Terms Explained

Moon Surface and Temperature Features

1. **Permanently Shadowed Regions (PSRs) -** Dark regions near lunar poles receiving little/no direct sunlight; crater rims block solar illumination; preserve water-ice, volatiles
2. **Doubly Shadowed Craters -** Smaller craters within larger PSRs; shielded from both direct sunlight and scattered light/thermal radiation; extremely cold
3. **Volatile Trap/Cold Trap -** Ultra-cold region where volatile substances (water vapour) freeze, remain preserved for long geological periods
4. **Lobate-Rim Morphology -** Flow-like or tongue-shaped crater rim indicating possible ice-rich subsurface excavation

Radar Technology Terms

1. **DFSAR (Dual Frequency Synthetic Aperture Radar) -** Radar instrument on Chandrayaan-2 using microwave signals studying lunar surface, shallow subsurface even in dark polar regions
2. **Radar Polarimetry -** Method studying how polarization of radar waves changes after reflection; infers surface roughness, buried material, possible ice-rich deposits
3. **CPR (Circular Polarization Ratio) -** Radar parameter comparing returned circularly polarized signals; high CPR alone indicates rough terrain OR ice

4. Why is this Discovery Significant?

In-Situ Resource Utilization (ISRU)

1. Mapping possible subsurface ice deposits critical for future lunar exploration
2. Lunar ice could potentially be used to -
    1. Extract drinking water for astronauts
    2. Generate oxygen for life support
    3. Produce hydrogen-oxygen rocket propellant (electrolysis splitting water into H_2 and O_2)

Fuel for Deep-Space Missions

1. Accessible lunar water converted into propellant
2. Moon becoming strategic refuelling hub for future missions to Mars, beyond
3. Reducing cost, weight of Earth-launched missions

Chandrayaan-2's Continuing Scientific Value

1. Vikram lander did not achieve soft landing (2019) but orbiter operational
2. DFSAR payload providing high-resolution, fully polarimetric L-band, S-band radar observations
3. Demonstrating India's sustained space science capability
4. Contributing to global lunar science despite partial mission success

5. India's Lunar Exploration Programme

Chandrayaan-1 (2008)

1. Discovered hydroxyl molecules, water molecules on lunar surface through M3 (Moon Mineralogy Mapper)
2. Confirmed water ice in permanently shadowed regions

Chandrayaan-2 (2019)

1. Orbiter operational; Vikram lander crashed during soft landing attempt
2. DFSAR continuing polar ice research

3. Pragyan rover could not be deployed

Chandrayaan-3 (2023)

1. Successfully landed Vikram lander near lunar south pole (August 23, 2023)
2. India became 4th nation achieving lunar soft landing (after USA, USSR, China)
3. Pragyan rover confirmed sulphur, other elements near south pole
4. Confirmed thermal gradient between lunar surface and subsurface

6. Conclusion

Chandrayaan-2's new evidence of possible subsurface ice in Moon's south polar regions through DFSAR radar polarimetric analysis combining CPR>1.0 and DOP<0.13 criterion demonstrates orbiter's continuing scientific value despite 2019 lander failure. Doubly shadowed craters within Permanently Shadowed Regions acting as volatile traps preserve ancient water-ice under extreme cold conditions. Discovery is critical for ISRU enabling future lunar colonization (drinking water, oxygen, rocket propellant through electrolysis) and positioning Moon as strategic deep-space refuelling hub. Building on Chandrayaan-1's water molecule discovery (2008) and Chandrayaan-3's successful south pole landing (2023) confirming sulphur-thermal gradient, Chandrayaan-2's findings strengthen India's contribution to global lunar science advancing human understanding of Moon's resource potential for sustainable deep-space exploration.

Source - **https -//www.thehindu.com/sci-tech/science/chandrayaan-2-detects-possible-presence-of-subsurface-ice-near-south-pole-of-moon/article71031903.ece**