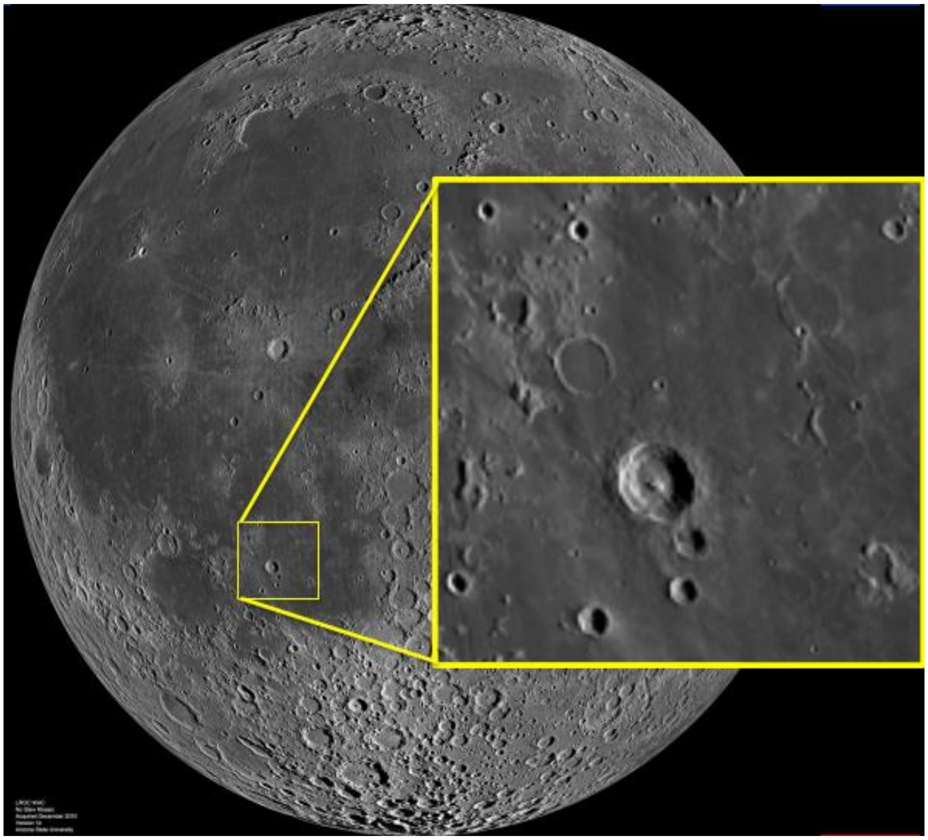
Water Detection - Bullialdus Crater
Team Name : REJN



➢ OBJECTIVE:

The key focus is to search for evidence for water on Moon, to understand the origin of the moon from mineral and chemical composition studies, map the lunar surface in greater detail and to detect and identify the presence of atomic species in the thin atmosphere of the Moon.

➢ TEAM MEMBERS:

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➢ SCOPE:

- **From 2008 to 2010, a series of discoveries led to a surprising conclusion: there is water on the Moon! Water and other volatile elements were detected in lunar volcanic glasses, suggesting hydration of the mantle.**
- **NASA & ISRO have discovered water ice on the Moon's poles. Future human habitats on the Moon could tap into this water ice for drinkable water, breathable air & rocket fuel.**

❖ INSTRUMENTS USED FOR THE PROCESS:

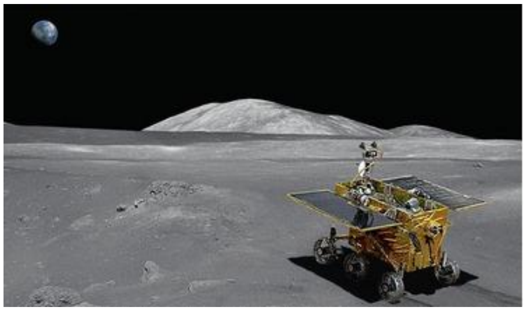
Evidence for surface water came from the Moon Mineralogy Mapper (M3) experiment on Chandrayaan-1. Initially it showed the presence of water on the sunlit side using water/ice spectral signature (2- 2.5 microns) in the reflected sunlight.

Chandrayaan 1 and Technology Used to Find Water on the Moon:

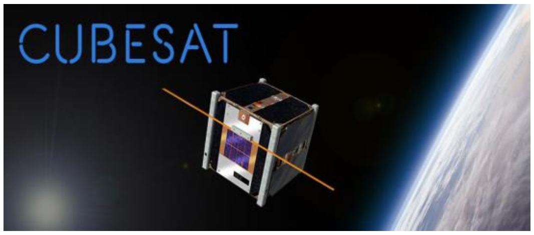
- India's first lunar probe Chandrayaan 1 has confirmed the presence of frozen water deposits on the Moon.
- NASA has confirmed through a statement on its website that a group of scientists has observed definitive evidence of water on the Moon.
- NASA says that the frozen water deposits are patchily distributed on the darkest and coldest areas and could also be ancient.
- ISRO's **Chandrayaan-2** instrument detects hydroxyl, water molecules on the Moon.

Moon Mineralogy Mapper and Instruments from Other Countries

- In 2009, M3 provided the first mineralogical map of the lunar surface and discovered water molecules in the polar regions of the moon.
- The instrument that detected frozen water on the surface of the Moon is M3 or Moon Mineralogy Mapper, which was NASA's contribution to Chandrayaan 1.
- M3 is basically an imaging spectrometer that provides a spectral map of the entire lunar surface thereby providing information also on the minerals it constitutes.
- NASA has also said on its website that based on M3's findings, water could be accessible as a resource for future expeditions to explore and even stay on the Moon
- Some other instruments from other countries are X-ray fluorescence spectrometer, Sub-keV Atom Reflecting Analyzer or SARA, SIR 2, Mini-SAR and Radiation Dose Monitor Experiment or RADOM-7.
- M3 has previously already confirmed that the moon was once in a completely molten state.
- This theory is popularly known as the magma ocean hypothesis. ISRO's TMC has also found and captured pictures of the landing site of the US aircraft Apollo 15.



❖ COMMUNICATION SYSTEM TO BE USED:



- The CubeSat is a new concept emerged after the year 2000, new standards and regulations were introduced by the different organizations and institutes to control the process of designing, building and launching the CubeSat's.
- The main microcontroller is an Arduino microcontroller that communicates with a commercial-of-the-shelf transceiver (RFM22), a half-duplex link which has been designed after performing the required link budget calculations.
- The frequency chosen for operation is the regulated 435 MHz, with TX power of 100 mW for the space unit and a data rate of 1200 b/s and 9600 b/s for beacon and payload signals, respectively.
- The communication algorithm, beacon and payload encoding and decoding algorithms have been designed using the Arduino programming language and a new packet coding technique introduced to increase the communication link reliability.

➢ WORKING OF CUBESAT:

1. The 30-pound CubeSat, proposed, designed and built by a team at Arizona State University (ASU), will be deployed by SLS once within the lunar vicinity. From there, the tiny spacecraft will use ion propulsion to conduct its own lunar flyby, then wait to be gravitationally captured into lunar orbit.
2. The spacecraft will then spiral into a very elliptical polar orbit which will take it as low as 10- to 25-km above the lunar South Pole and some 4,000-km above the lunar North Pole. And it will do so at a tiny fraction of the cost of a conventional NASA planetary science mission.
3. Once deployed, its solar arrays unfold, the spacecraft powers on, finds the Sun, and starts charging the batteries
4. The mission's primary goal is to measure the spatial distribution and extent of hydrogen enrichments at the lunar South Pole's permanently shadowed craters. If there is an enrichment within a region of less than 20 sq.-km, then Luna-HMap will be able to resolve it
5. The CubeSat spacecraft is equipped with a star tracker, an x-band radio, a command and data handling system, power control system, ion propulsion system and its primary science instrument --- a miniaturized neutron spectrometer.
6. The spectrometer measures high-energy galactic cosmic ray interactions with hydrogen embedded in the lunar surface

How does the spectrometer detect such hydrogen interactions with neutrons from cosmic rays?

- With each hydrogen collision, these neutrons lose about half their energy. Therefore, the energy distribution of neutrons emitted from the lunar surface is a good proxy for the amount of hydrogen and water ice within the top meter of the lunar surface.
- Detection of more high-energy neutrons indicates less water ice; while fewer high-energy neutrons indicate more water ice. But the goal is to create a detailed map of the hydrogen abundance within and around these permanently shadowed regions.

The biggest puzzle that this mission might solve?

- We don't understand the distribution of water-ice within permanently shadowed regions of the lunar poles. There is a theory that the irregular distribution from one crater to the next is due to the wobble of the Moon's poles over geologic time.

- As the ancient Moon's poles changed position, regions that are currently not in permanent shadow may have been in shadow in the past. So, traces of water ice and water-rich compounds may still linger, despite those regions no longer being in permanent shadow. But only the craters that were previously in permanent shadow at prior pole positions would have significant enrichment.

❖ POWER SOURCES:

1. Solar Source

Primary source become solar energy as it is available in abundance. But also, batteries are also provided as sometimes the spacecraft and the rover moves away from the
sunlight.

Most common source of power in satellites is solar. Solar panels use sunlight to generate electricity required to power the satellite. Photovoltaic modules use light energy (photons) from the Sun to generate electricity through the photovoltaic effect. The majority of modules use wafer-based crystalline silicon cells or thin-film cells. Recent advancements in solar cell technology make it possible to harness Sun's energy with considerable efficiency (around 25%). Newer cells based on Gallium Arsenide (GaAs) have higher efficiencies as compared to Silicon (Si) cells and also degrade slower in the harsh space environment.

Efficiency of power generated by solar panels is dependent on temperature, intensity and angle at which rays strikes the panels.

Selection of cells:

- Solar panels need to have a sufficient surface area that can be pointed towards the Sun as the spacecraft moves to get enough power.
- Also, the efficiency of panels need to be considered i.e. how much power is generated per square unit of area when it is sunlit

- The materials used to make the solar panels should be such that it can sustain in space where temperature and other conditions can change rapidly.
- We need also to determine the arrangement of PV modules (how many in series and in parallel). This is determined by voltage and current requirements of components.

Simulations:

- It is necessary to find out how much power is being generated in an orbit to know whether that power be enough to sustain the satellite. This can be done by doing simulation.

2. Fuel Cells:

They are usually used where environmental conditions don't allow solar panels to be used (either not enough sunlight or temperature beyond the range of operating temperature of solar panels).
A fuel cell combines a fuel (hydrogen or hydrogen source) with an oxidizer (oxygen or air) to produce electrical power. Like a battery, a fuel cell has two electrodes (a cathode and an anode) that are separated by an electrolyte. However, unlike batteries, the electrode is not consumed in a fuel cell, and the cell can produce electricity as long as more fuel and oxidizer are pumped through it.
At present fuel cells cannot be used on CubeSat's but research is going on this topic.

3. Radioisotope power system:

- An **atom** is a tiny building block of matter. Almost everything we know in the universe is made up of atoms. Atoms have to store a lot of energy to hold themselves together. But, some atoms—called **radioisotopes**—are unstable and begin to fall apart. As the atoms fall apart, they release energy as heat.
- A **radioisotope power system** uses the temperature difference between the heat from the unstable atoms and the cold of space to produce electricity. NASA has used this type of system to power many missions. For example, it has powered missions to Saturn, Pluto and even spacecraft that have traveled to interstellar space. This type of power system also provides the energy for the Curiosity rover on Mars.

4. Batteries (Rechargeable):

- Spacecraft batteries are designed to be tough. They need to work in extreme environments in space and on the surfaces of other worlds. The batteries also need to be recharged many times. Over time, NASA scientists have invented ways to improve these batteries. Now they can store more energy in smaller sizes and last longer.
- Rechargeable batteries are important for load levelling. They are commonly used on satellites to provide continuous power while the satellite moves in and out of sunlight. Curiosity uses a rechargeable lithium-ion battery pack to power large temporary loads while the rover's RTG provides a lower, constant amount of power.

❖ HUMAN RESOURCES:

Any Space Programs requires skilled Human Resources in respective areas who all in together will contribute in successful completion of the mission. It encompasses all the stages right from planning the mission till creating useful insights from the data collected. Let's dig into different human resources involved in the mission:

- **Design and Research Team:**
  This department is responsible for planning the whole mission, drafting the timeline. They will research all the processes, instruments, functionating involved in the mission. They will design the Launch Vehicle, the Orbiter, the Instruments and Devices required. They will also decide what data has to be collected and how will it be collected.
  - **Rocket Scientists**
  - **Communications Scientists**
  - **Meteorologists and Geologists**
  - **Astronomers**
  - **Design and Research Manager**

- **Manufacturing, Assembly, Testing Team:**
  This team will be responsible for building of the Launch Vehicle, Orbiter, the Launch Facility. They will also foresee procurements of instruments, materials which are not in-house. They will ensure that all manufacturing and complete assembly is done within design standards and further test the components in simulation to avoid losses and failures.
  - **Engineers**
  - **Fabricators**
  - **Workers**
  - **Test Rig Operators**
  - **Supervisors**
  - **MAT Manager**

- **Launch Team:**
  This department will be responsible for successful execution of Vehicle Launch, and escape of the Orbiter out of earth's atmosphere into the orbit of the moon. They will oversee all the Launch conditions so as not cause any harm to the mission. The weather conditions, atmospheric conditions are monitored to green flag the mission or make any adjustments. Also, the ongoings of the mission are commented in

speech to keep track of the mission for the Team as well as general public.

- **Launch Directors**
- **Launch Test Directors**
- **Launch Weather Officer**
- **Vehicle manager**
- **Launch Commentator**
- **Safety and Mission Assurance Officer**
- **Launch Manager**

- **Telemetry, Tracking and Communications Team:**
  This Team is responsible for ensuring that the data is being transferred from the Command Center to the Orbiter and vice-versa. This ensures that Orbiter is given proper commands to continue in the required orbits. The tracking of the Orbiter is done continuously to see its current location in the orbit of moon and verify the progress. The data collected by the Orbiter has to be effectively sent to the command center which has to be worked on.
  - **Remote Sensing Specialist**
  - **Tele-Communications Engineer**
  - **Radiologist**
  - **Space Surveillance Specialist**
  - **TTC Manager**

- **Data Engineering and Artificial Intelligence Team:**
  The data sent by Orbiter in its raw form can be of no use. So, it has to be processed and stored in proper format and in database so it can be easily accessed by AI Scientists. The AI scientists will then analyze the data, manipulate it and draw some meaningful insights from it. It is similar to work done in the coding part. This result in mapping the moon's surface to detect and locate the presence of water as trapped ice under the moon's surface.
  - **Data Engineers**
  - **Artificial Intelligence Scientists**
  - **Radiologists**
  - **DE/AI Manager**

There will be a Mission Manager who will coordinate with all the managers and collectively take decisions required for smooth progress of the mission.

Future Scope:

Research into more efficient solar panels is ongoing, primarily for providing power on Earth. The future of RTGs is in question due to the limited supply of fuel, but NASA is investigating producing small quantities of Pu-238 for space missions. Radioisotope-powered Sterling engines are a possible improvement to current RTGs. Like RTGs, such an engine uses a block of radioactive material as a heat source, but instead of thermocouples it uses a heat engine to operate a generator.