The Correlation between CME and Water Production on the Moon

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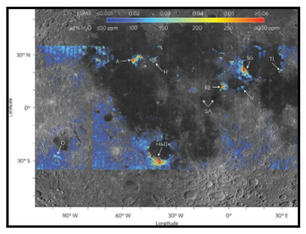
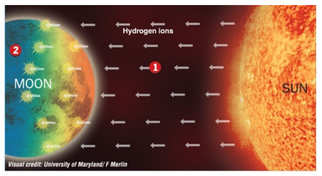
Introduction

Not much is known about the sources of water on the Moon. An article by D.M. Hurley concludes that chemical sputtering by the solar wind is the most plausible source mechanism to convert H^+ to H2, which then travels up to the permanently shadowed poles on the Moon and freezes into ice.

The team decided to look for other sources for water formation on the Moon, specifically the Sun's coronal mass ejections (CME). When the Sun releases a CME, a cloud of magnetized plasma brings in a higher influx of protons and electrons at a higher speed than normal conditions. We wanted to investigate if a CME is a significant source for water formation on the Moon given that sputtering of elements will affect the water production rate during the time period of a CME.



Water deposits on the Moon Surface- Nature Geo Science



Solar sputtering ejects particles from the Sun in direction towards the Moon. Hydrogen is one of the most common particles in the ejecta and can combine with free oxygen in the moon to create water. -University of Maryland

Research Question

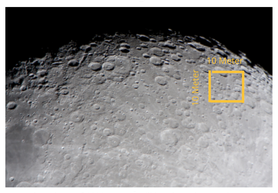
Is there a higher production of water on the Moon during the event of a CME?

Hypothesis

If a CME hits the Moon, then there will be a higher water production because the higher influx of protons and helium nuclei increases the sputtering of oxygen atoms to form water molecules with the increase amount of hydrogen atoms.

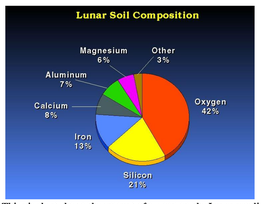
Data Analysis

Testing Area



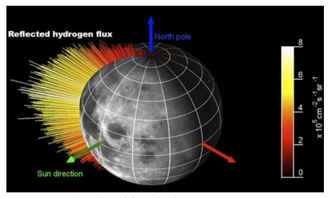
the volume of 1000 meters^3 will be where the experiment will take place

**This is merely a representation of area and is not to scale*



This pie chart shows the amount of oxygen on the Lunar regolith

This gave the team a basis as to how much oxygen is to be expected once we had our data. However, oxygen would be the limiting reagent.



The reflected flux of hydrogen on the Moon

This was part of the research that lead to the flux that was computed, finding the amount of free hydrogen in the exosphere.

Organized Data

	Control Experiment	Speed of 1000 km/sec	Speed of 2000 km/sec	Speed of 3000 km/sec
Amount of Hydrogen (atoms x 10^{12} x m^{-3})	$4.52 \cdot 10^{-5}$	80301.264	40096.867	26767.094
Amount of Oxygen (atoms x 10^{7} x m^{-3})	$1 \cdot 10^{-3}$	2.45	4.99	7.49

Note: The amount of water molecules produced will have the same numerical value as the same amount of oxygen released in the exosphere, due to the fact that the number of oxygen atoms to water molecules in a water synthesis equation is one.

To obtain theoretical oxygen density values for after a CME event:

1) We took the average values taken from an experiment found in an article, in which we only manipulated the helium concentration to sputter yield to a He concentration of 3.85%
2) Then we manipulated the sputter yield gotten from a 3.85% concentration and the speed to get varying yields for our different values of speed
3)Finally, we used the ratio between the original sputter yield and the oxygen density calculated by them to get the different oxygen densities depending on the speed

To obtain the hydrogen particle values:

1) We took the average particle flux and found the supposed hydrogen particle flux by using the ratio of 25 hydrogen atoms to 26 total particles
2) The time, in the seconds , it would take a CME to pass for the varying speeds, assuming the depth of a CME is 0.3 AU at its deepest were calculated.
3) Finally, the hydrogen that would hit the Moon was measured by multiplying the time by the particle flux of hydrogen from a CME. Then we subtracted the product minus the product of the time multiplied by the flux multiplied times the hydrogen backscatter ratio, 16%.

Methodology

We agreed to look at the events during normal conditions on the satellite and during a CME to compare the results.

The volume of 1000 meters cubed was chosen for our experiment's target area to simulate water production in a given volume. The location is not specified on the Moon as water production can occur all over the body.

CME are highly concentrated of hydrogen and helium ions. helium was observed to have the ability to break ionic compounds containing the element oxygen. oxygen is plentiful in the lunar regolith, as 42% of lunar regolith compounds are composed of oxygen atoms. The element (oxygen) is not found in the lunar exosphere, due to the large molar mass of the oxygen atoms. The theory is that hydrogen and helium ions will enter the Moon's exosphere and then helium ions will sputter oxygen particles into the exosphere. That is where the the hydrogen and oxygen atoms will combine to form into the famous covalent compound known as H_2O.

Conclusion and After thoughts

The hypothesis we constructed was supported by our experiment's research. At max velocity, a CME can produce 26767.094 atoms. With the tremendous increase of particles that come from CMEs and the higher amount of oxygen sputtered, the production rate of water will increase during this time frame.

Our project was created by running into multiple dead ends in our research phase of our project. If we could do this project again, we would delve deeper into more research in order to find more accurate information and data. This way we wouldn't have to use any theoretical data or data that is assumed upon by supported data that is unrelated to our research question.

Application of Our Research

The Moon possesses the potential to become the first stop in Earth's exploration of space. A possible increase of water on the Moon could help future missions in space.Water has the potential use of creating rocket fuel and air. The satellite can be used therefor as an area for refueling or stocking up on materials such as water and breathable air. The future explorers will no longer have to use Earth as their only source of water, as the Moon will become their alternative source. This reduction of transporting water will also save a tremendous amount of money of about $25,000 per gallon, which can be used in other programs.

Citations

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