

## Moons

### *A paradigm shift?*

[MUSIC PLAYING]

#### **NARRATOR:**

Since even before the days of space exploration, humans have longed to find water on other celestial bodies.

#### **PAUL SPUDIS:**

Water is a very useful substance, it can be used to support human life, it can be used to shield us from radiation. In its component form, in the two gases hydrogen and oxygen, it's the most powerful chemical rocket propellant known.

If you could refuel once you get to orbit with water derived from space, effectively you could go anywhere you want to in the Solar System.

#### **NARRATOR:**

The Apollo missions opened the door to our understanding of the history and composition of our Moon. But they offered no sign that our search for water on Earth's one and only natural satellite would be fruitful.

#### **MAHESH ANAND:**

Immediately after the Apollo missions there were many, many hundreds and thousands of scientists who were actually interested in looking at these Moon rocks, they looked at it very carefully with the instrumentation that they had available to them, and a paradigm appeared, which basically said that there is absolutely no water either on the Moon or inside the Moon.

#### **JESSICA BARNES:**

When the answer came back basically, no there isn't, everyone was a bit like, ugghhh. It was thought that the Moon was a completely un-hydrous, bone-dry body.

#### **NARRATOR:**

But was it? In 1994, the Clementine mission sent back surprising radar data from within

permanently shadowed craters near the Moon's poles.

**PAUL SPUDIS:**

I had always been sceptical about the idea of ice on the Moon; I never really believed it. We improvised an experiment with Clementine to beam radio waves into the dark area and then listen to the echoes looking for a signature of ice. We found what we thought was that signature near the South Pole, now that got us really excited.

**NARRATOR:**

This signature was confirmed, beyond a shadow of a doubt, in 2009, when a rocket section from NASA's Lcross probe was crashed into the shadowed part of the polar crater Cabeus. The puff of gas flung up from the impact contained about 5% water.

It had probably collected in this polar cold trap, molecule by molecule, from the vapourised remains of icy comets striking the Moon over millions of years. But what about inside the Moon? Was it really bone dry?

In 2008 a key instrument carried on board India's first lunar orbiter, Chandryaaan-1, answered that million-dollar question.

**CARLE PIETERS:**

This particular instrument measures solar radiation reflected from the Moon to look for absorption features that different minerals have.

**NARRATOR:**

Low and behold, the Moon mineralogy mapper revealed traces of water both in craters and in minerals all over the Moon.

**CARLE PIETERS:**

When these confirmations came in I was elated, that was, that was an epiphany, a delight.

**JESSICA BARNES:**

So, when all these results came out, it was sort of like, we've got to go back to the samples, because we know there's water on the surface, and that suggests ok, there might be water in the rocks.

G. JEFFREY TAYLOR: Now forty years later we find out, ohh, that there is water inside the Moon.

**MAHESH ANAND:**

Forty years on we have more sophisticated and more sensitive instrumentation. There is no question that the recent discovery has rejuvenated the lunar community.

**KATHARINE ROBINSON:**

Everyone is still trying to work out where the water came from, I mean some of it could have been inherited from the giant impact with the earth that formed the Moon. But, it's also possible that it was delivered very early in the Moons history. And this is all still very young science; we're still trying to work that out now.

**NARRATOR:**

However, water inside the Moon isn't quite in the H<sub>2</sub>O form one finds on Earth.

**MAHESH ANAND:**

We are mostly talking about Hydroxyl, which is an oxygen combined with a hydrogen atom. As such, water as we know it, liquid water doesn't exist in the lunar interior or inside the Moon. It's actually the ingredients of that water which exist. And, therefore, we say that it is water.

**NARRATOR:**

We now know there are traces of water from within the Moon inside lunar minerals. And significant concentrations of cometary ice that have accumulated in craters near the poles. But, would a polar Moon base be guaranteed a good supply of drinking water?

G. JEFFREY TAYLOR: You would think oh I can just chip off a piece, melt it, gulp it down. But the problem is that it might have other volatile substances; there's methane, there's probably even cyanide [laughs]. Really all the Apollo hands who did a lot of chemistry on the Moon even wrote a paper entitled 'Don't drink the water' [laughs]. You may have to do some chemistry on the water to make sure you can drink it.

**NARRATOR:**

Nevertheless, the presence of water in and on the Moon could be the key to reaching new boundaries in human space exploration.

**CARLE PIETERS:**

If you have abundant water on the Moon, then you can harvest it and use it as a fuel by breaking it into the hydrogen and oxygen.

**PAUL SPUDIS:**

So, finding water not only enables human life to have a foothold in space, it also permits you to create a space transportation system that is reusable, that's refuelable and extensible. I consider it the difference between a cave man floating on a log off a beach, to actually building the first sea going ship, and crossing the ocean to a new continent.

**NARRATOR:**

But we have only just begun to grasp the scale of this discovery and to uncover its part in the Moon's fascinating story.

**KATHARINE ROBINSON:**

We thought for so many years since Apollo that the Moon was completely anhydrous. Which is funny when you're coming from Earth when there's water everywhere. Now we're trying to figure out what happened to it, or how much there is. We don't know the answers to any of these questions yet. So, it's a pretty exciting field to be in because it's moving along so quickly.