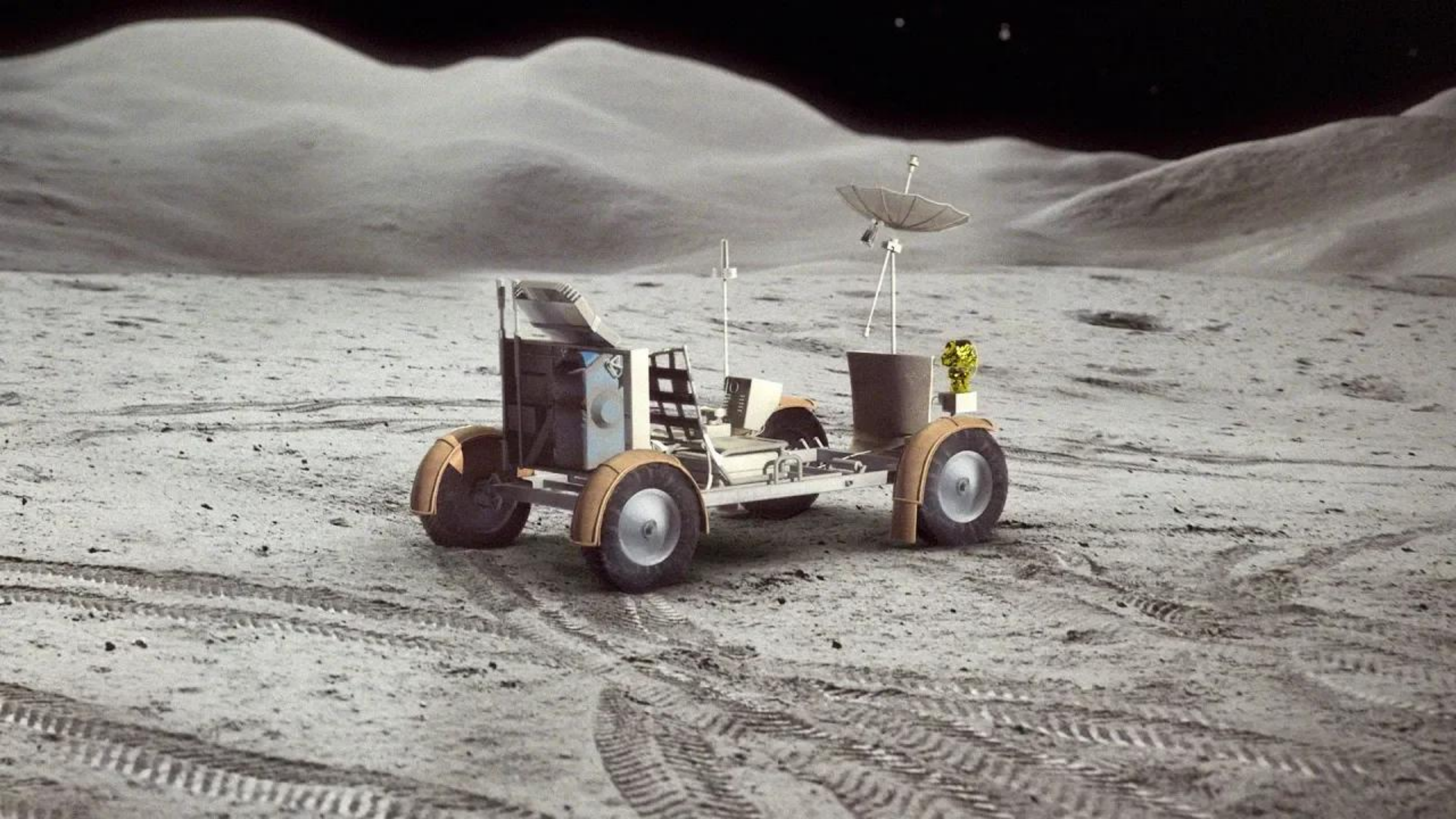

1
00:00:00,067 --> 00:00:01,602
[music]

2
00:00:01,602 --> 00:00:04,304
Compared to Earth, the
moon appears to be perfectly dry

3
00:00:04,304 --> 00:00:07,841
and airless, but in fact it
possesses an extremely sparse

4
00:00:07,841 --> 00:00:11,044
atmosphere, barely
thicker than a vacuum.

5
00:00:11,044 --> 00:00:15,215
From late 2013 to early 2014,
a NASA mission called LADEE

6
00:00:15,215 --> 00:00:18,352
explored the lunar
atmosphere and dust environment.

7
00:00:18,352 --> 00:00:21,655
Now, LADEE's observations have
led to a new discovery about the

8
00:00:21,655 --> 00:00:23,357
moon's water.

9
00:00:23,357 --> 00:00:27,127
During the initial exploration
of the moon, and the analysis of

10
00:00:27,127 --> 00:00:29,329
all the returned samples
from the Apollo and the Luna

11
00:00:29,329 --> 00:00:32,666

missions, we thought that the
surface of the moon was dry.

12
00:00:32,666 --> 00:00:37,170
But more recent missions, like
Lunar Prospector, LCROSS, and

13
00:00:37,170 --> 00:00:40,540
Lunar Reconnaissance Orbiter,
have not only shown that the

14
00:00:40,540 --> 00:00:44,611
surface of the moon has a
global hydration, but there are

15
00:00:44,611 --> 00:00:48,949
actually high concentrations
of ice water in the permanently

16
00:00:48,949 --> 00:00:52,319
shadowed regions
of the lunar poles.

17
00:00:52,319 --> 00:00:55,122
In the decades following the
Apollo program, a series of

18
00:00:55,122 --> 00:00:58,425
robotic explorers revealed
tantalizing hints of water on

19
00:00:58,425 --> 00:01:00,794
the moon, challenging the
conclusion that the moon was

20
00:01:00,794 --> 00:01:02,195
dry.

21
00:01:02,195 --> 00:01:05,666
The first definitive discovery

of water was made in 2008 by the

22
00:01:05,666 --> 00:01:08,135
Indian mission Chandrayaan-1,
which detected hydroxyl

23
00:01:08,135 --> 00:01:11,238
molecules spread across the
lunar surface and concentrated

24
00:01:11,238 --> 00:01:13,006
at the poles.

25
00:01:13,006 --> 00:01:15,842
The following year, NASA's
LCROSS mission deliberately

26
00:01:15,842 --> 00:01:18,745
impacted part of its launch
vehicle into the southern crater

27
00:01:18,745 --> 00:01:22,516
Cabeus, ejecting a plume
that contained water ice.

28
00:01:22,516 --> 00:01:25,652
These discoveries showed that
the moon harbors water, and that

29
00:01:25,652 --> 00:01:28,689
the highest concentrations occur
within darkened craters at the

30
00:01:28,689 --> 00:01:29,790
poles.

31
00:01:29,790 --> 00:01:32,993
But questions remained about the
abundance of water at the moon's

32
00:01:32,993 --> 00:01:34,528
mid latitudes.

33
00:01:34,528 --> 00:01:37,998
Now, data from LADEE are
beginning provide answers.

34
00:01:37,998 --> 00:01:42,135
What we discovered is that the
surface releases its water when

35
00:01:42,135 --> 00:01:44,705
the moon is bombarded
by micrometeoroids.

36
00:01:44,705 --> 00:01:48,542
This is especially noticeable
during meteor showers.

37
00:01:48,542 --> 00:01:52,145
What we also found is that the
surface that's releasing the

38
00:01:52,145 --> 00:01:56,316
water is being protected by a
layer, a few centimeters of dry

39
00:01:56,316 --> 00:02:00,754
soil that can only be breached
by large micrometeoroids.

40
00:02:00,754 --> 00:02:03,890
When micrometeoroids impact the
surface of the moon, most of the

41
00:02:03,890 --> 00:02:06,493
material in the
crater is vaporized.

42

00:02:06,493 --> 00:02:10,397
There is also a shock wave
that propagates outward.

43
00:02:10,397 --> 00:02:14,668
That shock wave carries enough
energy to release the water

44
00:02:14,668 --> 00:02:17,137
that's coating the
grains of the soil.

45
00:02:17,137 --> 00:02:20,307
Most of that water will get
released into space, and that's

46
00:02:20,307 --> 00:02:23,543
the signature that LADEE detects
with its instrument from its

47
00:02:23,543 --> 00:02:24,778
orbit.

48
00:02:24,778 --> 00:02:27,948
LADEE observed water being
released from within the moon,

49
00:02:27,948 --> 00:02:30,784
but the micrometeoroids
impacting the moon's surface

50
00:02:30,784 --> 00:02:33,653
have a more
exotic origin: comets.

51
00:02:33,653 --> 00:02:35,956
When Earth passes through
the leftover debris trail of a

52
00:02:35,956 --> 00:02:39,059

comet, small particles of
rock and dust burn up in our

53
00:02:39,059 --> 00:02:41,995
atmosphere,
creating a meteor shower.

54
00:02:41,995 --> 00:02:43,964
On the moon, these
micrometeoroids impact the

55
00:02:43,964 --> 00:02:47,734
surface, releasing water at the
same time that meteor showers

56
00:02:47,734 --> 00:02:49,770
are occuring on Earth.

57
00:02:49,770 --> 00:02:52,105
By analyzing the data
returned by the neutral mass

58
00:02:52,105 --> 00:02:56,043
spectrometer, we found that the
intensity and the frequencies of

59
00:02:56,043 --> 00:02:59,212
the fluctuations of signals
from the water to be perfectly

60
00:02:59,212 --> 00:03:01,381
correlated with
known meteor streams.

61
00:03:01,381 --> 00:03:04,718
For example, we were able to
detect a big spike of water

62
00:03:04,718 --> 00:03:07,854
during the Geminid meteor shower

that occurred in December of

63
00:03:07,854 --> 00:03:10,390
2013.

64
00:03:10,390 --> 00:03:12,793
Knowing how much water is
available at the moon's mid

65
00:03:12,793 --> 00:03:16,296
latitudes is important
for future exploration.

66
00:03:16,296 --> 00:03:18,732
LADEE's observations show
that beneath three inches of dry

67
00:03:18,732 --> 00:03:21,868
lunar soil is a wet
layer ten feet deep.

68
00:03:21,868 --> 00:03:24,771
But on the moon,
"wet" is a relative term.

69
00:03:24,771 --> 00:03:29,276
The concentration of water in
the wet layer is about 200-500

70
00:03:29,276 --> 00:03:31,144
part per million per weight.

71
00:03:31,144 --> 00:03:34,114
\hSo, to fill an eight-ounce
bottle with lunar water, you

72
00:03:34,114 --> 00:03:37,451
would need to squeeze water
out of about one to two thousand

73
00:03:37,451 --> 00:03:39,019
pounds of lunar soil.

74
00:03:39,019 --> 00:03:43,056
So, while the wet surface is
wet, it's drier than you think.

75
00:03:43,056 --> 00:03:46,460
The search for water on the moon
spans five decades, and is of

76
00:03:46,460 --> 00:03:48,628
great interest to
future exploration.

77
00:03:48,628 --> 00:03:51,665
Thanks to LADEE, we now know
that trace amounts of water are

78
00:03:51,665 --> 00:03:54,734
widely distributed across the
lunar surface, improving our

79
00:03:54,734 --> 00:03:57,804
understanding the moon's
geologic past and its continued