



SEPTEMBER 26, 2020

International
Observe the Moon
Night



1
00:00:06,133 --> 00:00:09,933
Hi everyone - Dennis Andrucyk -
Goddard Center Director. I'd

2
00:00:09,933 --> 00:00:12,500
like to thank you all for
joining me and celebrating

3
00:00:12,500 --> 00:00:16,533
International Observe the Moon
Night. It's truly a great event,

4
00:00:16,533 --> 00:00:20,833
and to taking a look up and
seeing 250,000 miles away our

5
00:00:20,833 --> 00:00:24,900
own Moon and understanding what
it means to us. I'll tell you

6
00:00:24,900 --> 00:00:28,433
what, as a kid when I was nine
years old when the Apollo 11

7
00:00:28,433 --> 00:00:31,333
landed on the surface of the
Moon and Neil Armstrong took

8
00:00:31,333 --> 00:00:35,200
that first giant leap for
humankind - it was an

9
00:00:35,200 --> 00:00:37,566
inspirational event. But at the
time though I didn't fully

10
00:00:37,566 --> 00:00:41,366
appreciate what it meant. I
didn't realize 250,000 miles

11
00:00:41,366 --> 00:00:45,266
away there are people up on the
Moon - all I could think about

12
00:00:45,266 --> 00:00:47,733
is - how did they get there? And
more importantly how do they we

13
00:00:47,733 --> 00:00:51,366
gonna get them back? Sure enough
they did come back safely though

14
00:00:51,366 --> 00:00:56,100
and - it inspired me to think
about what the Moon does mean

15
00:00:56,100 --> 00:00:59,466
what it can mean and what it
will mean in the future. For

16
00:00:59,466 --> 00:01:02,733
many years though I wasn't sure
what science we could actually

17
00:01:02,733 --> 00:01:05,200
derive from the Moon or what
benefit we could derive from the

18
00:01:05,200 --> 00:01:08,133
Moon. But I'll tell you what, in
recent years scientists have

19
00:01:08,133 --> 00:01:12,333
proven that there's ice there.
We look towards - look towards

20
00:01:12,333 --> 00:01:15,266
the Moon to understand it -
understand what it means to our

21

00:01:15,266 --> 00:01:19,533

Earth - to look to see if we can
do - in situ resource

22

00:01:19,533 --> 00:01:22,866

utilization. Perhaps make fuel
with it through the Artemis

23

00:01:22,866 --> 00:01:26,266

program and to expand the
presence of humans to the Moon

24

00:01:26,266 --> 00:01:30,766

and then on to Mars. Truly truly
a great great opportunity for

25

00:01:30,766 --> 00:01:34,066

us. So the Moon means a whole
heck of a lot heck of a lot to

26

00:01:34,066 --> 00:01:37,266

me - and I know it means a whole
heck of a lot to the entire

27

00:01:37,266 --> 00:01:43,066

world. It's a great celestial
And I'm happy to really be a

28

00:01:43,066 --> 00:01:45,833

part of this event today. You
know, over the years there have

29

00:01:45,833 --> 00:01:49,266

been songs, poems, plays, books
and all sorts of artistic

30

00:01:49,266 --> 00:01:53,633

endeavors talking about the Moon
- so now I'd like to introduce

31
00:01:53,633 --> 00:01:57,166
Anne Kinney, the Goddard Deputy
Center Director - and Anne is

32
00:01:57,166 --> 00:01:59,833
going to celebrate an artistic
work that was created by a

33
00:01:59,833 --> 00:02:05,033
friend of hers. And I think it's
very interesting as well. So

34
00:02:05,033 --> 00:02:09,133
please join me in welcoming Anne
Kinney. Thanks very much Dennis.

35
00:02:11,200 --> 00:02:15,266
I would like to share with you a
poem, written by a good friend

36
00:02:15,266 --> 00:02:20,066
of mine Rebecca Elson who was
both an astronomer and a poet -

37
00:02:20,066 --> 00:02:25,366
and wrote a poem called "What if
There Were No Moon?" This this

38
00:02:25,366 --> 00:02:29,800
poem is a wonderful combination
of the poetics of the Moon

39
00:02:29,800 --> 00:02:32,800
together with the science of the
Moon, if you will, and in the

40
00:02:32,800 --> 00:02:37,633
background you can hear a
wonderful piece of music called

41
00:02:37,633 --> 00:02:43,300
"Claire de Lune - Light of the
Moon" played by Debussy himself

42
00:02:43,300 --> 00:02:48,300
the composer. So, what if there
were no Moon there would be no

43
00:02:48,333 --> 00:02:57,200
months, a still sea, no spring
tides, no bright nights,

44
00:02:57,200 --> 00:03:07,766
occultation of the stars, no
face no moon songs. Terror of

45
00:03:07,766 --> 00:03:18,366
eclipse - no place to stand and
watch the Earth rise. So the

46
00:03:18,366 --> 00:03:22,233
Moon means a great deal to us
and Dennis and I hope you will

47
00:03:22,233 --> 00:03:29,700
enjoy this celebration of our
dear near neighbor the Moon.

48
00:05:20,833 --> 00:05:08,800
[Music]

49
00:05:20,833 --> 00:05:25,500
The Moon. It's our nearest neighbor
in space, and data we gather

50
00:05:25,500 --> 00:05:28,433
from its features can tell us a
lot about the rest of our solar

51

00:05:28,433 --> 00:05:33,166
system. And through the eyes of
the LRO spacecraft, we can

52

00:05:33,166 --> 00:05:37,533
explore the lunar surface in all
new ways in fascinating detail.

53

00:05:37,533 --> 00:05:41,600
Our tour begins on the western
border, where the near side of

54

00:05:41,600 --> 00:05:45,166
the Moon meets the far side. The
enormous feature is a lunar

55

00:05:45,166 --> 00:05:51,033
crater and it's known as the
Orientale basin. Here, LRO's

56

00:05:51,033 --> 00:05:53,833
terrain map combines with
surface gravity measurements

57

00:05:53,833 --> 00:05:57,033
from the GRAIL mission. This
data reveals structure in the

58

00:05:57,033 --> 00:06:00,300
lunar crust, beneath the
surface, giving us a window into

59

00:06:00,300 --> 00:06:06,200
the geologic features of the
Moon's interior. Our next

60

00:06:06,200 --> 00:06:09,433
location receives little direct
sunlight and has some of the

61

00:06:09,433 --> 00:06:12,466
coldest recorded temperatures in
the solar system – the South

62

00:06:12,466 --> 00:06:16,566
Pole. The highlighted spots
signify potential water ice,

63

00:06:16,566 --> 00:06:20,333
based on temperature readings
from LRO's Diviner instrument

64

00:06:20,333 --> 00:06:25,966
and reflectance from its laser
altimeter LOLA. LOLA also allows

65

00:06:25,966 --> 00:06:29,500
us to peer into the darkness of
Shackleton crater by bringing us

66

00:06:29,500 --> 00:06:37,900
this digital elevation model.
It's 21 kilometers wide, and 4

67

00:06:37,900 --> 00:06:41,533
kilometers deep, but it pales in
comparison to the largest known

68

00:06:41,533 --> 00:06:45,366
impact crater in the Earth-Moon
system – the South Pole-Aitken

69

00:06:45,366 --> 00:06:54,700
Basin. Sitting on the far side,
it's 2500 km across and 13 km

70

00:06:54,700 --> 00:06:59,200
deep. We don't yet know exactly
how old the basin is, but it was

71

00:06:59,200 --> 00:07:02,633

first seen in the 1960s by
spacecraft flying around the far

72

00:07:02,633 --> 00:07:09,900

side. As much as we use LRO data
to investigate areas we can't

73

00:07:09,900 --> 00:07:13,666

see from Earth, we also probe
familiar territory on the lunar

74

00:07:13,666 --> 00:07:17,600

near side, to bring back images
with an all new level of detail.

75

00:07:17,600 --> 00:07:22,633

This is Tycho crater; it's
around 100 million years old.

76

00:07:28,333 --> 00:07:31,366

Here, the Lunar Reconnaissance
orbiter camera captures the

77

00:07:31,366 --> 00:07:35,933

central peak with a 100
meter-wide bolder at the summit

78

00:07:35,933 --> 00:07:40,666

– the origins of which are still
a mystery. Continuing across

79

00:07:40,666 --> 00:07:44,133

Moon's nearside, we will arrive
in an area ripe for future

80

00:07:44,133 --> 00:07:47,933

exploration, due to the
diversity of impact and volcanic

81

00:07:47,933 --> 00:07:52,266

materials. It features a prominent crater so bright it's

82

00:07:52,266 --> 00:07:55,200

not only visible through telescopes, but also to the

83

00:07:55,200 --> 00:07:59,666

naked eye. Welcome to the Aristarchus plateau. Here,

84

00:07:59,666 --> 00:08:03,633

infrared shows the mineral pyroxene in orange, and a splash

85

00:08:03,633 --> 00:08:07,200

of plagioclase in blue from Aristarchus crater. This region

86

00:08:07,200 --> 00:08:13,166

can tell us a lot about the rich volcanic history of the Moon. As

87

00:08:13,166 --> 00:08:16,533

much as we study the Moon looking for sites to visit, we

88

00:08:16,533 --> 00:08:21,000

also look back at places we've already been. This is because

89

00:08:21,000 --> 00:08:23,766

the new data that LRO is gathering helps us reinterpret

90

00:08:23,766 --> 00:08:27,000

the geology of familiar places, giving scientists a better

91

00:08:27,000 --> 00:08:31,633
understanding of the sequence of
events in early lunar history.

92

00:08:31,633 --> 00:08:35,033
Here, we descend to the Apollo
17 landing site in the

93

00:08:35,033 --> 00:08:38,933
Taurus-Littrow valley, which is
deeper than the Grand Canyon.

94

00:08:38,933 --> 00:08:41,333
The path the astronauts took
over the course of three days is

95

00:08:41,333 --> 00:08:49,000
shown. The Lunar Reconnaissance
Orbiter camera is even able to

96

00:08:49,000 --> 00:08:52,333
capture a view of the bottom
half of the Apollo 17 Lunar

97

00:08:52,333 --> 00:08:55,800
Lander, which still sits on the
surface, as well as the rover

98

00:08:55,800 --> 00:09:01,100
vehicle. These images help
preserve our accomplishment of

99

00:09:01,100 --> 00:09:07,400
human exploration on the Moon's
surface. Moving onward, we make

100

00:09:07,400 --> 00:09:10,933
our way to our final
destination. This location

101

00:09:10,933 --> 00:09:14,633

contains regions that exist in permanent shadow, as well as

102

00:09:14,633 --> 00:09:18,566

ones that bask in nearly perpetual light. It's the North

103

00:09:18,566 --> 00:09:22,233

Pole. Detailed terrain measurements by LOLA allow

104

00:09:22,233 --> 00:09:25,300

scientists to model sunlight and shadow at the poles over decades

105

00:09:25,300 --> 00:09:29,833

and centuries. Sunlit peaks and crater rims here may be ideal

106

00:09:29,833 --> 00:09:33,300

locations for generating solar power for future expeditions to

107

00:09:33,300 --> 00:09:37,300

the Moon. This updated visualization of the lunar

108

00:09:37,300 --> 00:09:40,266

landscape stands as a testament to the functionality and

109

00:09:40,266 --> 00:09:42,133

abilities of the Lunar Reconnaissance Orbiter

110

00:09:42,133 --> 00:09:46,966

spacecraft. And as the mission continues to gather data, it

111

00:09:46,966 --> 00:09:50,166
will provide us with many more
opportunities to take a tour of

112
00:09:50,166 --> 00:09:54,166
our Moon.

113
00:09:59,933 --> 00:10:04,333
[beeping]

114
00:10:07,733 --> 00:10:37,000
[Music]

115
00:10:37,000 --> 00:10:44,766
■ Have you ever wanted
to fly among the stars? To see ■

116
00:10:44,766 --> 00:10:54,400
■ up close what we could only see
from afar. Come on let's go your ■

117
00:10:54,400 --> 00:11:04,266
■ dreams are possible. We can fly
far away from here. Defying ■

118
00:11:04,266 --> 00:11:14,000
■ gravity we'll soar beyond the
atmosphere. We will see things ■

119
00:11:14,000 --> 00:11:22,366
■ we've never seen before. We'll
open up a door to a new world ■

120
00:11:22,366 --> 00:11:30,033
■ and go explore the Moon and so
much more. ■

121
00:11:30,033 --> 00:11:35,266
[music]

122

00:11:35,266 --> 00:11:39,533

■ I remember dreaming ■

123

00:11:39,533 --> 00:11:48,800

■ that I could take flight - to
chase forever into the heart of ■

124

00:11:48,800 --> 00:11:58,433

■ the night. Above it all, the
world's so small. We can fly far ■

125

00:11:58,433 --> 00:12:06,233

■ away from here. Defying gravity
we'll soar beyond the ■

126

00:12:06,233 --> 00:12:16,266

■ atmosphere. We will see things
we've never seen before - ■

127

00:12:16,266 --> 00:12:25,500

■ open up a door to a new world and go
explore, the Moon there's so much ... ■

128

00:12:25,500 --> 00:12:33,666

■ more that we have yet
to see, much more to understand. ■

129

00:12:33,666 --> 00:12:44,766

■ But the time is here and now.
After all we're just one speck ■

130

00:12:44,766 --> 00:12:57,866

■ of sand in this universe of
ours. We can fly far away from ■

131

00:12:57,866 --> 00:13:08,433

■ here. Defying gravity we'll soar
beyond the atmosphere (yyyeah) ■

132

00:13:08,433 --> 00:13:16,266

■ We can see things we've never
seen before. We'll open up a ■

133

00:13:16,266 --> 00:13:27,333

■ door to a new world and go
explore - the Moon and so much more. ■■

134

00:16:12,066 --> 00:13:36,666

[music]

135

00:16:21,033 --> 00:16:24,233

Hey - I'm Jacob Richardson
at NASA Goddard Space Flight Center

136

00:16:24,233 --> 00:16:26,400

and I'm a planetary
Geologist, and I study

137

00:16:26,400 --> 00:16:30,666

volcanoes. NASA studies
volcanoes because not only are

138

00:16:30,666 --> 00:16:33,966

volcanoes actively erupting
every day on the Earth, but

139

00:16:33,966 --> 00:16:37,333

there are also hundreds and
thousands of volcanoes on all

140

00:16:37,333 --> 00:16:39,633

sorts of planets around the
solar system and maybe even

141

00:16:39,633 --> 00:16:43,500

beyond to other solar systems.
So today I'll show you a

142

00:16:43,500 --> 00:16:47,566

demonstration where you can safely erupt your own small

143

00:16:47,566 --> 00:16:50,766
volcano inside your home. And to start, let's look at what a

144

00:16:50,766 --> 00:16:54,500
volcano is. So, since I study volcanoes I've drawn one for you

145

00:16:54,500 --> 00:16:57,900
here on this piece of paper and you can see that volcanoes are

146

00:16:57,900 --> 00:17:02,566
often mountains and they often have holes in the center. So

147

00:17:02,566 --> 00:17:07,466
let's look at the inside of this volcano. Here I've drawn the

148

00:17:07,466 --> 00:17:12,400
volcanic vent. This is the pathway filled with magma where

149

00:17:12,400 --> 00:17:16,866
magma goes from the inside of a planet to the outside - and you

150

00:17:16,866 --> 00:17:21,133
can see it's erupting right now. So this is our model that we

151

00:17:21,133 --> 00:17:26,033
have here. And magma is made up of three different things: We

152

00:17:26,033 --> 00:17:31,400

have molten rock, we have solid rock, and we have gas. And all

153

00:17:31,400 --> 00:17:35,500
of these inside of a volcanic vent that we have as our cup are

154

00:17:35,500 --> 00:17:40,300
all mixed together waiting to erupt. So here we have a film

155

00:17:40,300 --> 00:17:46,133
canister that will represent the volcanic gas that's inside of

156

00:17:46,133 --> 00:17:50,000
the magma in our demonstration. Now when magma comes up closer

157

00:17:50,000 --> 00:17:55,066
to the surface of any planet, the gas expands, and when it

158

00:17:55,066 --> 00:17:57,933
gets very close to the surface expands very quickly and that

159

00:17:57,933 --> 00:18:01,766
causes explosive eruptions. So in this demonstration we need to

160

00:18:01,766 --> 00:18:06,500
fill this with a gas that will expand until the film canister

161

00:18:06,500 --> 00:18:08,566
will break apart.

162

00:18:08,566 --> 00:18:10,800
[explosion sound]

163

00:18:12,533 --> 00:18:14,400

What you'll need for this demonstration are

164

00:18:14,400 --> 00:18:18,733

safety goggles, some film
canisters - we got ours on the

165

00:18:18,733 --> 00:18:23,733

internet - and some alka-seltzer
tablets or effervescence

166

00:18:23,733 --> 00:18:29,866

tablets, some spare change -
also some table tennis balls, a

167

00:18:29,866 --> 00:18:35,600

clear plastic cup, and some
water. All right - so first

168

00:18:35,600 --> 00:18:38,800

we'll put on our safety goggles.
And now that we have these on we

169

00:18:38,800 --> 00:18:43,066

can begin doing some science. So
I'll take one of these film

170

00:18:43,066 --> 00:18:47,300

canisters, and to weigh it down
I'll load it up with our spare

171

00:18:47,300 --> 00:18:50,233

change. This will just add
weight so it doesn't go flying

172

00:18:50,233 --> 00:18:55,833

during this experiment. Now I'm
going to take our volcanic vent

173

00:18:55,833 --> 00:19:00,200

and put it in the center of the table, and move everything else

174

00:19:00,200 --> 00:19:06,266

a little far away from it. And I have my solids ready to go to

175

00:19:06,266 --> 00:19:11,366

put into the volcano right before it erupts. So, to make

176

00:19:11,366 --> 00:19:14,700

the gas we're going to use effervescing tablets, and we're

177

00:19:14,700 --> 00:19:16,933

also going to use some water. So I'm going to fill this film

178

00:19:16,933 --> 00:19:21,400

canister up with just a little bit of water - maybe halfway

179

00:19:21,400 --> 00:19:28,300

would be fine. The next part's a little quick. We're just going

180

00:19:28,300 --> 00:19:33,133

to add this tablet into this film canister and close it up

181

00:19:33,133 --> 00:19:38,400

good and tight and put it inside of our volcanic vent facing up.

182

00:19:38,400 --> 00:19:40,933

And then we're going to put the ping pong balls right on top of

183

00:19:40,933 --> 00:19:45,066

that, and stand back and watch.

Let's do it.

184

00:20:03,300 --> 00:19:58,300

[popping sounds]

185

00:20:06,033 --> 00:20:06,966

So there you have it -

186

00:20:06,966 --> 00:20:09,200

your own volcanic eruption.

187

00:20:09,200 --> 00:20:12,566

[eruption sounds]

188

00:20:12,566 --> 00:20:15,866

So now let's do this just a little bit bigger.

189

00:20:17,633 --> 00:20:19,833

How about a

trash can volcano?

190

00:20:20,100 --> 00:20:22,333

[explosion sounds]

191

00:20:22,333 --> 00:20:25,733

So in this trash can volcano

everything will be a little bit bigger.

192

00:20:25,733 --> 00:20:29,266

Instead of a plastic cup we'll

use a plastic trash can. Instead

193

00:20:29,266 --> 00:20:34,033

of ping pong balls for the solid

rock, we'll use wiffle balls.

194

00:20:34,033 --> 00:20:38,133

And now we'll add some water for
the molten rock for the gas

195

00:20:38,133 --> 00:20:41,500

instead of a film canister we're
going to upgrade to an empty

196

00:20:41,500 --> 00:20:45,833

soda pop bottle. And instead of
effervescence tablets and water,

197

00:20:45,833 --> 00:20:49,233

we're actually going to be using
liquid nitrogen in this to make

198

00:20:49,233 --> 00:20:52,800

the eruption. Liquid nitrogen is
really cold and we're going to

199

00:20:52,800 --> 00:20:56,933

use these gloves which are
insulated to protect our hands

200

00:20:56,933 --> 00:21:00,866

from any exposure to that. All
right we're ready to get

201

00:21:00,866 --> 00:21:05,233

started. And to get some help
I've enlisted my NASA colleague

202

00:21:05,233 --> 00:21:09,400

Caela Barry to help me pour this
liquid nitrogen into our soda

203

00:21:09,400 --> 00:21:14,400

pop bottle. Are you ready?
Ready!

204

00:21:47,333 --> 00:21:55,900
[explosion sounds]

205
00:22:04,500 --> 00:22:06,133
So the science demonstrations

206
00:22:06,133 --> 00:22:10,000
that you saw today are exactly
the same thing that happens in

207
00:22:10,000 --> 00:22:13,566
volcanoes on Earth, and in the
ancient pasts of the Moon and

208
00:22:13,566 --> 00:22:18,066
Mars and maybe present-day
Venus. Now what happens in the

209
00:22:18,066 --> 00:22:23,400
volcano to make it explosive is
that the gas very quickly

210
00:22:23,400 --> 00:22:27,066
expands, and that creates some
sort of a bubble that sometimes

211
00:22:27,066 --> 00:22:31,300
bursts and makes these explosive
eruptions. So, in other planets

212
00:22:31,300 --> 00:22:34,900
where they have thicker or
thinner atmospheres, that can

213
00:22:34,900 --> 00:22:39,200
make explosions smaller or
bigger. And that's what we study

214
00:22:39,200 --> 00:22:40,333
here at NASA Goddard.

215

00:22:41,366 --> 00:22:46,766

[music]

216

00:22:48,766 --> 00:22:51,266

Welcome,

I'd like to talk to you today

217

00:22:51,266 --> 00:22:57,700

about geology and art. My name
is Sarah Noble and I'm a lunar

218

00:22:57,700 --> 00:23:01,266

geologist and also an artist.

Here I am in the desert playing

219

00:23:01,266 --> 00:23:06,433

with some Moon rovers and this
is one of my paintings. At its

220

00:23:06,433 --> 00:23:09,566

most basic level, art can be
broken down into just five

221

00:23:09,566 --> 00:23:15,833

elements: shape, line, color,
value, and texture. For the most

222

00:23:15,833 --> 00:23:18,233

part, these are the same clues
that geologists use when we look

223

00:23:18,233 --> 00:23:21,233

at images of other planets to
understand what is happening and

224

00:23:21,233 --> 00:23:24,133

what processes have shaped the
planet's surface. Let's take a

225

00:23:24,133 --> 00:23:29,066

closer look at each of these elements. The first one is

226

00:23:29,066 --> 00:23:32,833

shape. The most common shape we find across the Solar System are

227

00:23:32,833 --> 00:23:36,400

circles. These often indicate impact craters. There is a lot

228

00:23:36,400 --> 00:23:39,300

of stuff floating around our Solar System and sometimes bits

229

00:23:39,300 --> 00:23:43,400

run into other bits and leave behind these scars. This crater

230

00:23:43,400 --> 00:23:46,166

– Linne Crater – on the Moon, is one of my favorites, because

231

00:23:46,166 --> 00:23:53,333

it's so perfectly round. But not all craters are. Here is an

232

00:23:53,333 --> 00:23:55,866

image from the surface of Callisto, one of Jupiter's

233

00:23:55,866 --> 00:23:59,166

moons, and you can see that most of the craters here are

234

00:23:59,166 --> 00:24:02,466

round-ish, but they aren't perfectly round. Things like the

235

00:24:02,466 --> 00:24:06,233

angle of impact, the existing
topography, the underlying

236

00:24:06,233 --> 00:24:09,633

structure, and post-impact
slumping and modifications can

237

00:24:09,633 --> 00:24:14,733

all influence the exact shape.
You will find things though that

238

00:24:14,733 --> 00:24:18,100

are definitely not round. Blobby
shapes usually indicate

239

00:24:18,100 --> 00:24:22,166

volcanoes, like in this image of
Ina D, it's one of a mysterious

240

00:24:22,166 --> 00:24:27,500

class of lunar volcanic features
called "IMPs" – irregular mare patches.

241

00:24:27,500 --> 00:24:30,100

IMPs are a hot topic
among lunar geologists today,

242

00:24:30,100 --> 00:24:33,633

some think these features are
ancient, billions of years old,

243

00:24:33,633 --> 00:24:36,400

while others think that they are
really young, only tens of

244

00:24:36,400 --> 00:24:41,000

millions of years old. That's
really young to a geologist.

245

00:24:41,000 --> 00:24:43,300

Figuring out which is true will
have big implications for how we

246

00:24:43,300 --> 00:24:45,866

think the Moon cooled, because
up until recently we thought

247

00:24:45,866 --> 00:24:51,700

that all volcanism on the Moon
stopped about a billion years ago.

248

00:24:51,700 --> 00:24:54,533

Sometimes blob shapes can
indicate lakes, but we don't

249

00:24:54,533 --> 00:24:57,500

have any of those on our Moon.
There is one moon in our Solar

250

00:24:57,500 --> 00:25:00,900

System that does though, it's
Titan. Titan is one of Saturn's

251

00:25:00,900 --> 00:25:03,733

moons. If you look at it with
your naked eye, it just looks

252

00:25:03,733 --> 00:25:06,033

like a big orange ball because
it has this thick hazy

253

00:25:06,033 --> 00:25:08,966

atmosphere. But, if you look at
it in certain wavelengths, you

254

00:25:08,966 --> 00:25:11,433

can see through the haze and
below it are these amazing

255

00:25:11,433 --> 00:25:16,500

lakes. They're not filled with water, like our lakes on Earth,

256

00:25:16,500 --> 00:25:18,700

it is way too cold out there for liquid water. Instead they are

257

00:25:18,700 --> 00:25:21,833

filled with liquid methane. But we think that Titan has a

258

00:25:21,833 --> 00:25:24,400

methane cycle that works just like our water cycle, with

259

00:25:24,400 --> 00:25:30,600

clouds and rain and streams and lakes. Pretty cool. Okay, moving

260

00:25:30,600 --> 00:25:34,900

on to Line. Lines come in two basic varieties, straight and

261

00:25:34,900 --> 00:25:38,300

curvy. Straight lines are often a sign of tectonic activity,

262

00:25:38,300 --> 00:25:41,166

like these awesome faults and fractures on Pluto's moon

263

00:25:41,166 --> 00:25:44,600

Charon. Whereas, curvy lines usually suggest something is

264

00:25:44,600 --> 00:25:49,333

flowing, like a meandering stream, or a lava flow. We do

265

00:25:49,333 --> 00:25:52,400

have lines on the Moon from
tectonic activities, they are

266

00:25:52,400 --> 00:25:55,033

smaller and not quite as
impressive as the ones on

267

00:25:55,033 --> 00:25:58,333

Charon. These little faults are
called "wrinkle ridges" and we

268

00:25:58,333 --> 00:26:01,166

find them all over the Moon.
Some of them, like the ones

269

00:26:01,166 --> 00:26:05,066

shown here, are really young.
How do we know they are young?

270

00:26:05,066 --> 00:26:08,333

Well, can you see how they cut
through most of the craters in

271

00:26:08,333 --> 00:26:11,333

this image? That means that the
crater had to already be there

272

00:26:11,333 --> 00:26:14,800

when the ridge formed, which
means the ridge is younger. We

273

00:26:14,800 --> 00:26:18,166

think that these ridges may be
forming even today. The Moon is

274

00:26:18,166 --> 00:26:21,500

still cooling, and as it cools
it shrinks, these ridges are the

275

00:26:21,500 --> 00:26:27,600

result of that contraction.

Okay, color. Color also comes in

276

00:26:27,600 --> 00:26:31,900

two varieties, true color and

added. "True color" means what

277

00:26:31,900 --> 00:26:34,600

your eye would see if you looked

through a big telescope, or

278

00:26:34,600 --> 00:26:38,166

visited in person. Here are some

true color images of Jupiter's

279

00:26:38,166 --> 00:26:41,166

biggest moons. Isn't it amazing

that they are all so different

280

00:26:41,166 --> 00:26:46,800

from each other? The Moon's true

color is pretty boring, it

281

00:26:46,800 --> 00:26:49,433

really is pretty much just

shades of grey. But as

282

00:26:49,433 --> 00:26:52,800

geologists, we often use color

to help us visualize things.

283

00:26:52,800 --> 00:26:55,300

Like the image on the left here

uses color to represent

284

00:26:55,300 --> 00:26:57,900

different kinds of mineralogy to

help us understand what the

285

00:26:57,900 --> 00:27:01,266

variation in composition is
across the Moon's surface. On

286

00:27:01,266 --> 00:27:04,833

the right, the colors represent
topography, reds and yellows are

287

00:27:04,833 --> 00:27:11,300

high points, blues and purples
are low. So here is one

288

00:27:11,300 --> 00:27:14,566

place where artists and
geologist's use different words.

289

00:27:14,566 --> 00:27:17,833

Artists use the term "value"
while geologists have their own

290

00:27:17,833 --> 00:27:21,866

word, "albedo," but they pretty
much mean the same thing, how

291

00:27:21,866 --> 00:27:25,566

light or dark something is. The
Moon has some great examples of

292

00:27:25,566 --> 00:27:28,233

this. Here are a couple of
beautiful impact craters on the

293

00:27:28,233 --> 00:27:32,033

Moon, look at the amazing
patterns of light and dark. This

294

00:27:32,033 --> 00:27:34,900

happens because the Moon is
exposed to the space environment

295

00:27:34,900 --> 00:27:38,100

which causes the surface to get darker over time, but when you

296

00:27:38,100 --> 00:27:41,366

get an impact, it pulls up fresh material from below that's still

297

00:27:41,366 --> 00:27:44,266

bright. These are fresh craters, but over time, these bright

298

00:27:44,266 --> 00:27:50,200

patterns will fade away. The Moon also has these other cool

299

00:27:50,200 --> 00:27:53,466

patterns, called "swirls" that are like my favorite thing.

300

00:27:53,466 --> 00:27:56,400

Aren't they beautiful? They're also mysterious. We don't know

301

00:27:56,400 --> 00:27:59,200

what causes these to form. We know that it is related to

302

00:27:59,200 --> 00:28:01,666

magnetic fields in the rocks below them, but we don't know

303

00:28:01,666 --> 00:28:06,833

what caused the magnetic fields, or why the patterns appear.

304

00:28:06,833 --> 00:28:09,600

Okay, our last element is texture, which is a bit hard to

305

00:28:09,600 --> 00:28:13,466

show in two dimensions. Texture is the quality of the surface.

306

00:28:13,466 --> 00:28:17,200

Is it rough, is it smooth? What do you think of the textures in

307

00:28:17,200 --> 00:28:20,500

these images from the Lunar Reconnaissance Orbiter Camera?

308

00:28:20,500 --> 00:28:22,633

Can you imagine what it would it feel like to walk across these

309

00:28:22,633 --> 00:28:27,866

surfaces in bare feet? So that's it, we covered all five

310

00:28:27,866 --> 00:28:31,000

elements. I hope you learned a little bit about lunar geology

311

00:28:31,000 --> 00:28:32,966

tonight, and I hope I inspired you to create some of your own

312

00:28:32,966 --> 00:28:35,800

lunar art. I wanted to end by sharing a couple of my

313

00:28:35,800 --> 00:28:41,866

paintings, so you can see how I use shape, line, color, value,

314

00:28:41,866 --> 00:28:45,666

and texture to interpret the Moon. The top one of these is of

315

00:28:45,666 --> 00:28:48,166

one of those lunar swirls we
just talked about, and you can

316

00:28:48,166 --> 00:28:51,400

see how I used value -
highlights and shading, to give

317

00:28:51,400 --> 00:28:54,233

the crater some dimension and
texture, and to make it seem

318

00:28:54,233 --> 00:28:57,600

three-dimensional. The bottom
painting is a more abstracted

319

00:28:57,600 --> 00:29:00,966

landscape and you can see how I
used line and color to focus the

320

00:29:00,966 --> 00:29:04,466

viewer's attention on the oasis
that is the Earth hovering over

321

00:29:04,466 --> 00:29:08,766

the alien landscape of the
Moon's surface. Now it's your

322

00:29:08,766 --> 00:29:11,900

turn. Go forth and make some
art. And if you are so inclined,

323

00:29:11,900 --> 00:29:13,833

please share it with us, I would
love to see what your

324

00:29:13,833 --> 00:29:15,600

imagination unleash!

325

00:30:15,566 --> 00:30:08,933

[music]

326

00:30:15,566 --> 00:30:17,833

Watching Apollo footage of astronauts

327

00:30:17,833 --> 00:30:21,233

doing geology on the surface of
the Moon is a really great way

328

00:30:21,233 --> 00:30:24,733

to think about preparing for
Artemis - for putting people on

329

00:30:24,733 --> 00:30:29,966

the Lunar surface once again. We
learn a lot in how they did

330

00:30:29,966 --> 00:30:32,366

science operations on the Moon
and what it's like to work on

331

00:30:32,366 --> 00:30:35,333

the Moon. You see them doing
geology, you see them taking

332

00:30:35,333 --> 00:30:38,966

rock samples, putting in a drive
tube to take a core sample. You

333

00:30:38,966 --> 00:30:41,866

see them bouncing along the
surface of the Moon on the Lunar

334

00:30:41,866 --> 00:30:45,333

rover that they used in Apollo
15 through 17. So it's a great

335

00:30:45,333 --> 00:30:48,733

way to help drive technology

development for the next

336

00:30:48,733 --> 00:30:52,400
generation of spacesuits and
geology sampling tools. There's

337

00:30:52,400 --> 00:30:56,566
these facilities that help us
train like we are on the Lunar

338

00:30:56,566 --> 00:31:01,100
surface. You know these
one-sixth G offload systems or

339

00:31:01,100 --> 00:31:04,466
putting people in the aquatic
environment are great ways to

340

00:31:04,466 --> 00:31:07,933
train the mobility part, right,
like what can you do and how

341

00:31:07,933 --> 00:31:11,800
different does it feel to be in
one-sixth G and do these tasks.

342

00:31:11,800 --> 00:31:15,033
We've been training astronauts
in geology and geoscience for

343

00:31:15,033 --> 00:31:18,366
decades now. The Apollo
astronauts had literally

344

00:31:18,366 --> 00:31:21,433
hundreds of hours of training in
geology before they flew to the

345

00:31:21,433 --> 00:31:24,300
Moon. It's often said that the

Apollo astronauts had the

346

00:31:24,300 --> 00:31:27,333

equivalent of a Master's degree
in geology by the time they flew

347

00:31:27,333 --> 00:31:30,733

to the Moon. In the intervening
decades since Apollo, we've been

348

00:31:30,733 --> 00:31:34,100

training astronauts who fly to
the International Space Station

349

00:31:34,100 --> 00:31:36,900

because when they're on
the ISS they spend time observing

350

00:31:36,900 --> 00:31:39,900

the Earth. Looking out the
window, taking pictures of what

351

00:31:39,900 --> 00:31:43,100

they see on the Earth's surface.
Now that we're looking at

352

00:31:43,100 --> 00:31:45,466

putting astronauts on the
surface of the Moon, we also

353

00:31:45,466 --> 00:31:48,800

take them into the field. We
take them to field sites here on

354

00:31:48,800 --> 00:31:52,266

Earth that resemble field sites
that we expect them to see on

355

00:31:52,266 --> 00:31:55,300

the Moon. That's the reason why

we take them out into places

356

00:31:55,300 --> 00:32:00,133
that are unique like volcanic
landscapes or places that are

357

00:32:00,133 --> 00:32:03,633
analogous to the Lunar surface
to train them on the scale and

358

00:32:03,633 --> 00:32:07,666
fidelity of science that you
just can't recreate in these

359

00:32:07,666 --> 00:32:10,433
facilities. And so by combining
this classroom and field

360

00:32:10,433 --> 00:32:12,766
training, we're able to prep
them for fundamentals of

361

00:32:12,766 --> 00:32:16,133
geology, the major driving Lunar
science questions that we have

362

00:32:16,133 --> 00:32:18,966
that we hope to address with the
Artemis Program, and teaching

363

00:32:18,966 --> 00:32:22,366
them how to do field work in
relevant, analogue environments.

364

00:32:22,366 --> 00:32:26,233
For just science aspects of
developing new spacesuits, can

365

00:32:26,233 --> 00:32:30,533
it get you to where you need to

go? And once you get there, can

366

00:32:30,533 --> 00:32:34,400
you do the cool science that you
need to do? And so that's: can

367

00:32:34,400 --> 00:32:37,866
you move effectively and
efficiently in the suit to be

368

00:32:37,866 --> 00:32:41,200
able to collect the samples or
use the tools or the

369

00:32:41,200 --> 00:32:44,033
instruments? For the visibility,
it's like: can you make the

370

00:32:44,033 --> 00:32:47,866
necessary observations that you
need to or, does the suit have

371

00:32:47,866 --> 00:32:51,433
the lights on it that it needs
to illuminate the surface and

372

00:32:51,433 --> 00:32:56,400
make the observations that you
need to? The Lunar South Pole

373

00:32:56,400 --> 00:32:59,766
holds tremendous resources that
are going to allow us to

374

00:32:59,766 --> 00:33:03,133
continue to explore. This is a
place that we've never been

375

00:33:03,133 --> 00:33:06,500
before. There's so much to be

learned from getting boots on

376

00:33:06,500 --> 00:33:10,100
the ground and exploring a
unique place that challenges us

377

00:33:10,100 --> 00:33:14,533
as humans and also helps us
develop technologies that make

378

00:33:14,533 --> 00:33:17,933
our everyday life that much
better. We think there might be

379

00:33:17,933 --> 00:33:21,366
volatiles present at the South
Pole. By using these volatiles,

380

00:33:21,366 --> 00:33:24,333
we'll be able to do things like:
create drinking water, create

381

00:33:24,333 --> 00:33:26,933
rocket fuel to launch astronauts
back to Earth. And so by

382

00:33:26,933 --> 00:33:29,833
harnessing the power of the
land, we'll be able to help

383

00:33:29,833 --> 00:33:33,533
astronauts establish that
long-term sustainable presence.

384

00:33:33,533 --> 00:33:42,633
[music]

385

00:33:42,633 --> 00:33:45,500
It's human nature to explore -
pushing our boundaries and

386

00:33:45,500 --> 00:33:48,566
exploring our universe is, I
think, just one of those things

387

00:33:48,566 --> 00:33:52,300
that's just stuck in our human
nature - and we need to do it in

388

00:33:52,300 --> 00:33:55,433
order to understand the world
around us - including our Earth

389

00:33:55,433 --> 00:33:59,066
and our Solar System.

390

00:34:07,266 --> 00:34:08,933
Hi everyone. Welcome again to

391

00:34:08,933 --> 00:34:11,966
International Observe the Moon
Night. I am Dr. Casey Honniball

392

00:34:11,966 --> 00:34:14,266
and I would like to tell you
about my search for water on the

393

00:34:14,266 --> 00:34:17,933
Moon. So, with the Artemis program,
NASA will land the first woman

394

00:34:17,933 --> 00:34:21,200
and next man on the Moon by year
2024 with the goal of building a

395

00:34:21,200 --> 00:34:24,633
sustainable human presence. But
in order to do this we must

396

00:34:24,633 --> 00:34:27,866
understand what and how much we
need to bring with us. The most

397
00:34:27,866 --> 00:34:31,933
important thing for human life
is water. An astronaut cannot

398
00:34:31,933 --> 00:34:34,100
survive on the Moon more than a
few days without drinkable

399
00:34:34,100 --> 00:34:37,733
water. This water can also be broken
down to provide breathable

400
00:34:37,733 --> 00:34:41,366
oxygen and to produce rocket
fuel allowing humanity to travel

401
00:34:41,366 --> 00:34:45,433
even farther into our Solar
System. But water is expensive

402
00:34:45,433 --> 00:34:47,866
to launch to space and so
finding water on the Moon that

403
00:34:47,866 --> 00:34:50,333
we can use is important for
building a sustainable human

404
00:34:50,333 --> 00:34:54,433
presence. Currently we do know
that water exists on the Moon from

405
00:34:54,433 --> 00:34:58,400
observations with spacecraft,
telescopes, and Apollo samples.

406

00:34:58,400 --> 00:35:01,333
But what we need to understand
is how much water is there and

407
00:35:01,333 --> 00:35:05,400
how can we extract it? So you
may be wondering well how did

408
00:35:05,400 --> 00:35:07,500
water get to the Moon in the
first place? Well there are a

409
00:35:07,500 --> 00:35:11,300
few ways. One way is when the
Moon was first formed and before

410
00:35:11,300 --> 00:35:15,166
it formed a solid surface comets
carrying water impacted the Moon

411
00:35:15,166 --> 00:35:18,466
and left behind water in the
lunar interior. This internal

412
00:35:18,466 --> 00:35:21,166
water would later be erupted
onto the surface of the Moon

413
00:35:21,166 --> 00:35:25,900
through volcanic events. Another
way is that water is created on

414
00:35:25,900 --> 00:35:28,566
the Moon through interactions of
solar wind with the lunar

415
00:35:28,566 --> 00:35:32,066
surface. Solar wind is mainly made up
of hydrogen and when this

416

00:35:32,066 --> 00:35:35,100

hydrogen hits the Moon it can
react with oxygen in lunar

417

00:35:35,100 --> 00:35:40,100

minerals and form water. And one
other major way water can get to

418

00:35:40,100 --> 00:35:43,100

the Moon is through recent
meteorite impacts. Meteorites,

419

00:35:43,100 --> 00:35:46,966

like comets can carry water to
the Moon or produce water during

420

00:35:46,966 --> 00:35:52,833

an impact. But where can we find
this water? Well it could be

421

00:35:52,833 --> 00:35:55,066

trapped inside permanently
shadowed regions at the lunar

422

00:35:55,066 --> 00:35:57,400

poles that are super cold
because they never receive

423

00:35:57,400 --> 00:36:02,066

any sunlight. At places like this
the water can be trapped as frost

424

00:36:02,066 --> 00:36:06,200

like you might see on your grass
on a cold winter morning. Water

425

00:36:06,200 --> 00:36:09,166

can also stick to the surfaces
of lunar grains as it hops

426

00:36:09,166 --> 00:36:11,800
around on the hot lunar surface
looking for a colder place to

427

00:36:11,800 --> 00:36:17,200
live or during a hop it could be
lost to space. Water from

428

00:36:17,200 --> 00:36:19,633
inside the Moon can be
trapped in volcanic glasses from

429

00:36:19,633 --> 00:36:24,000
when they erupted billions of
years ago. And lastly impacts

430

00:36:24,000 --> 00:36:28,433
can store water in glass, like
an insect trapped in amber. When

431

00:36:28,433 --> 00:36:31,666
a meteorite hits the Moon, it
melts some of the lunar surface,

432

00:36:31,666 --> 00:36:34,966
and experiments have shown that the
water from the meteorite can be

433

00:36:34,966 --> 00:36:39,500
trapped in the glass that forms
from the impact. So where this water

434

00:36:39,500 --> 00:36:42,066
lives is important for
understanding how to extract the

435

00:36:42,066 --> 00:36:48,266
water and use it as a resource.
So how do I study and look for

436

00:36:48,266 --> 00:36:51,700
hydration on the Moon? One way
is by looking at the Moon with

437

00:36:51,700 --> 00:36:55,666
the NASA infrared telescope
facility located in Hawaii shown

438

00:36:55,666 --> 00:36:59,666
in this top picture during a
lunar eclipse. Specifically, I

439

00:36:59,666 --> 00:37:02,700
look at the 3 micron infrared
wavelength that tells me if

440

00:37:02,700 --> 00:37:06,933
water and its close cousin hydroxyl
are present. What we find when

441

00:37:06,933 --> 00:37:10,066
we look at this 3 micron band is
that it changes in strength with

442

00:37:10,066 --> 00:37:14,600
lunar time of day, latitude, and
composition. This indicates that

443

00:37:14,600 --> 00:37:18,266
the amount of hydration on the
Moon is changing. This image of

444

00:37:18,266 --> 00:37:21,366
the Moon in the bottom corner
shows in blue where we are

445

00:37:21,366 --> 00:37:24,333
seeing hydration and showing how
the hydration is changing with

446

00:37:24,333 --> 00:37:29,566

latitude. But there's an issue with 3 micron band in that it

447

00:37:29,566 --> 00:37:33,866

cannot distinguish between water and hydroxyl. So in order

448

00:37:33,866 --> 00:37:36,900

to separate water and hydroxyl we created a new method for

449

00:37:36,900 --> 00:37:40,466

detecting purely water on the Moon. Instead of looking at the

450

00:37:40,466 --> 00:37:45,433

3 micron band we shift to 6 microns. Now this isn't a big shift

451

00:37:45,433 --> 00:37:49,866

but at 6 microns water has a unique spectral fingerprint.

452

00:37:49,866 --> 00:37:53,333

This technique is new to the Moon but 6 micron water has been

453

00:37:53,333 --> 00:37:57,000

detected on Apollo samples, meteorites, asteroids, and on

454

00:37:57,000 --> 00:38:01,633

Mars. 6 micron observations of the Moon are hard though because

455

00:38:01,633 --> 00:38:05,166

the Earth's atmosphere does not allow light at 6 micron to reach

456

00:38:05,166 --> 00:38:08,433
ground-based telescopes and
currently because this is new to

457

00:38:08,433 --> 00:38:12,033
lunar science, there are no
existing or planned lunar

458

00:38:12,033 --> 00:38:17,266
spacecraft capable of 6 micron
observations of the Moon.

459

00:38:17,266 --> 00:38:21,066
So instead we are using the NASA
Stratospheric observatory for

460

00:38:21,066 --> 00:38:24,800
infrared astronomy or SOFIA to
make the first observations of

461

00:38:24,800 --> 00:38:29,233
the Moon at 6 microns looking for
water. SOFIA is an airborne

462

00:38:29,233 --> 00:38:34,033
telescope flown on a Boeing 747
that flies at 45,000 feet. This

463

00:38:34,033 --> 00:38:36,800
picture on the left is me with
the SOFIA plane on my first

464

00:38:36,800 --> 00:38:40,200
observing run, the middle is the
SOFIA plane at sunset, and the

465

00:38:40,200 --> 00:38:45,933
right picture is me observing
the Moon inside the SOFIA plane.

466

00:38:45,933 --> 00:38:49,600
So how do the IRTF and SOFIA
telescopes support the Artemis

467
00:38:49,600 --> 00:38:53,133
program? With these two
telescopes we can map water and

468
00:38:53,133 --> 00:38:56,766
hydroxyl on the Moon. These maps
will allow us to estimate how

469
00:38:56,766 --> 00:39:00,633
much water versus hydroxyl is
present at different locations.

470
00:39:00,633 --> 00:39:04,000
One type of location that is of
particular interest is volcanic

471
00:39:04,000 --> 00:39:06,633
deposits because they may
concentrate water that can be

472
00:39:06,633 --> 00:39:13,066
used as a resource. So my future
work will use the IRTF and SOFIA

473
00:39:13,066 --> 00:39:16,500
telescopes to look at these volcanic
deposits like the Aristarchus

474
00:39:16,500 --> 00:39:19,633
region shown here. Currently we
know that these volcanic

475
00:39:19,633 --> 00:39:23,100
deposits have high hydration
through 3 micron observations

476

00:39:23,100 --> 00:39:26,200

but like I said before at 3
microns we cannot distinguish

477

00:39:26,200 --> 00:39:31,700

between water and hydroxyl. So with
the IRTF and SOFIA we can

478

00:39:31,700 --> 00:39:34,933

separate water from hydroxyl.
The maps we create of the

479

00:39:34,933 --> 00:39:37,800

volcanic deposits will provide
insights into the amount of

480

00:39:37,800 --> 00:39:42,833

water present and how to extract
it. If we find that these volcanic

481

00:39:42,833 --> 00:39:45,533

deposits on the Moon have high
abundance's of water, these may

482

00:39:45,533 --> 00:39:50,500

become landing sites for the Artemis
crews. And the water that they find can be used

483

00:39:50,500 --> 00:39:55,633

by the astronauts. Thank you
again for attending

484

00:39:55,633 --> 00:39:58,600

International observe the Moon
Night!

485

00:39:59,700 --> 00:40:00,900

[music]

486

00:40:00,900 --> 00:40:02,600

Fifty years ago we went

487

00:40:02,600 --> 00:40:07,733

to the Moon. We called it
Apollo. What many people don't

488

00:40:07,733 --> 00:40:13,966

know is that Apollo had a twin.
She was a woman named Artemis.

489

00:40:13,966 --> 00:40:19,933

Goddess of the Moon. We are
returning to the Moon... as a

490

00:40:19,933 --> 00:40:24,733

new generation of explorers.
This time to stay. And to

491

00:40:24,733 --> 00:40:29,066

prepare, to achieve humanity's
next giant leap, of sending the

492

00:40:29,066 --> 00:40:34,733

first human missions to Mars. We
believe our course will redefine

493

00:40:34,733 --> 00:40:37,400

what is possible. That we will
discover life-saving,

494

00:40:37,400 --> 00:40:40,833

Earth-changing science. And that
the challenges ahead will

495

00:40:40,833 --> 00:40:46,366

inspire generations. This is our
manifest. For all who wondered

496

00:40:46,366 --> 00:40:52,133

if we could return ... For all

who dreamed of pressing beyond ...

497

00:40:52,133 --> 00:40:57,800

this is your calling!

We go, for all of America.

498

00:40:57,800 --> 00:41:03,033

We go. We go, as the Artemis generation.

499

00:41:05,100 --> 00:41:06,833

We Go!

500

00:41:11,700 --> 00:41:21,066

[music]

501

00:41:21,066 --> 00:41:23,033

■ There you go, ■

502

00:41:23,033 --> 00:41:29,333

■ you got me believing in the power of a moonlit night. ■

503

00:41:29,333 --> 00:41:37,333

■ All I know is you give me that feelin' like I never want to tell you lies. ■

504

00:41:37,333 --> 00:41:46,166

■ And I just wanna take a chance - never let go of your hand - ■

505

00:41:46,166 --> 00:41:51,433

■ travel to the stars and back with you. ■

506

00:41:51,433 --> 00:41:55,466

■ On another moonlit night - ■

507

00:41:55,466 --> 00:42:01,733

■ Can you feel the magic
here tonight? The hours seem to fly - ■

508

00:42:01,733 --> 00:42:08,733

■ but hearts like yours and
mine, always beat in perfect time - ■