



## Ames Research Center

Question from NASA Center

1  
00:00:12,650 --> 00:00:11,150  
well good afternoon my name is Dwayne

2  
00:00:15,709 --> 00:00:12,660  
brown with the office of public affairs

3  
00:00:16,870 --> 00:00:15,719  
and welcome to NASA headquarters well

4  
00:00:19,640 --> 00:00:16,880  
ladies and gentlemen we have a

5  
00:00:22,340 --> 00:00:19,650  
two-for-one science special for you

6  
00:00:24,140 --> 00:00:22,350  
today NASA's Mars Reconnaissance Orbiter

7  
00:00:26,359 --> 00:00:24,150  
has made some incredible new findings

8  
00:00:29,570 --> 00:00:26,369  
and I watering images of the red planet

9  
00:00:32,450 --> 00:00:29,580  
and shortly following this briefing at

10  
00:00:34,220 --> 00:00:32,460  
around noon pacific 3 p.m. eastern on

11  
00:00:35,660 --> 00:00:34,230  
the west coast NASA's Jet Propulsion

12  
00:00:37,610 --> 00:00:35,670  
Laboratory will hold a media

13  
00:00:40,310 --> 00:00:37,620

teleconference to explain those new

14

00:00:42,350 --> 00:00:40,320

findings for the media joining us via

15

00:00:44,389 --> 00:00:42,360

television on the phone to participate

16

00:00:48,709 --> 00:00:44,399

in that media teleconference call the

17

00:00:53,029 --> 00:00:48,719

JPL newsroom in 818 35 45 0 1 1 that's 8

18

00:00:55,700 --> 00:00:53,039

183 5450 11 so we have mozz on the west

19

00:00:59,000 --> 00:00:55,710

coast and we have moon here on the East

20

00:01:00,889 --> 00:00:59,010

Coast and today scientists will put in

21

00:01:03,560 --> 00:01:00,899

further context and correct any

22

00:01:05,030 --> 00:01:03,570

misleading information about the new

23

00:01:07,700 --> 00:01:05,040

findings on the moon that have been

24

00:01:09,380 --> 00:01:07,710

reported we have a lot to cover I'll

25

00:01:11,810 --> 00:01:09,390

introduce our participants they'll give

26

00:01:14,450 --> 00:01:11,820

brief opening remarks and then we'll

27

00:01:18,560 --> 00:01:14,460

open it up for questions starting off

28

00:01:20,179 --> 00:01:18,570

will be Jim Green the director Planetary

29

00:01:21,740 --> 00:01:20,189

Science Division science Mission

30

00:01:26,120 --> 00:01:21,750

Directorate and NASA headquarters in

31

00:01:27,679 --> 00:01:26,130

Washington kali peters principal

32

00:01:30,920 --> 00:01:27,689

investigator for the moon mineralogy

33

00:01:35,240 --> 00:01:30,930

mapper otherwise known as M cube from

34

00:01:37,789 --> 00:01:35,250

Brown University rob green project

35

00:01:41,950 --> 00:01:37,799

instrument scientists for mq announces

36

00:01:45,080 --> 00:01:41,960

JPL in Pasadena California Roger Clark

37

00:01:47,450 --> 00:01:45,090

team member Cassini spacecraft visual

38

00:01:49,219 --> 00:01:47,460

and infrared mapping spectrometer and M

39

00:01:52,429 --> 00:01:49,229

cube co-investigator from the US

40

00:01:54,560 --> 00:01:52,439

Geological Survey in Denver and Jessica

41

00:01:56,780 --> 00:01:54,570

sunshine deputy principal investigator

42

00:01:59,929 --> 00:01:56,790

for NASA's Deep Impact extended mission

43

00:02:01,760 --> 00:01:59,939

and mq co-investigator Department of

44

00:02:04,130 --> 00:02:01,770

astronomy university of maryland college

45

00:02:07,069 --> 00:02:04,140

park let's get started I'll turn it over

46

00:02:09,020 --> 00:02:07,079

to Jim thank you very much going we're

47

00:02:11,900 --> 00:02:09,030

going to start today by putting the

48

00:02:13,640 --> 00:02:11,910

water story in context a historical

49

00:02:15,500 --> 00:02:13,650

perspective if you will

50

00:02:18,890 --> 00:02:15,510

and to do that we'll start at the

51  
00:02:21,880 --> 00:02:18,900  
beginning the generally accepted theory

52  
00:02:26,179 --> 00:02:21,890  
of the origin of the moon goes like this

53  
00:02:28,970 --> 00:02:26,189  
about 4.5 billion years ago an object

54  
00:02:32,899 --> 00:02:28,980  
perhaps the size of Mars slammed into

55  
00:02:35,539 --> 00:02:32,909  
the earth as these two objects reformed

56  
00:02:38,179 --> 00:02:35,549  
and the moon coalesced from that

57  
00:02:42,289 --> 00:02:38,189  
collision it lost most of its volatile

58  
00:02:44,179 --> 00:02:42,299  
and that includes water this theory is

59  
00:02:46,490 --> 00:02:44,189  
very consistent with the known

60  
00:02:49,369 --> 00:02:46,500  
observations of the earth-moon system

61  
00:02:52,039 --> 00:02:49,379  
that we have today and in fact it's

62  
00:02:54,649 --> 00:02:52,049  
quite consistent with the results from

63  
00:02:58,429 --> 00:02:54,659

the Apollo astronauts that brought back

64

00:03:00,949 --> 00:02:58,439

over 840 pounds of rock from the moon

65

00:03:04,069 --> 00:03:00,959

over several missions in the late 60s

66

00:03:07,399 --> 00:03:04,079

and 70s and in fact we have those rocks

67

00:03:10,250 --> 00:03:07,409

we've made those measurements and on the

68

00:03:13,910 --> 00:03:10,260

average there's about 50 parts per

69

00:03:16,429 --> 00:03:13,920

million of water in the lunar rocks so

70

00:03:19,460 --> 00:03:16,439

what does that mean if we were to

71

00:03:25,849 --> 00:03:19,470

extract all the water in the apollo

72

00:03:27,860 --> 00:03:25,859

rocks it would fill this tablespoon in

73

00:03:30,170 --> 00:03:27,870

other words the moon as we've known it

74

00:03:33,050 --> 00:03:30,180

based on our theories and based on the

75

00:03:36,680 --> 00:03:33,060

observations from Apollo is very very

76

00:03:40,220 --> 00:03:36,690

dry object the next part of our story is

77

00:03:44,240 --> 00:03:40,230

lunar prospector launched in late 90s

78

00:03:46,969 --> 00:03:44,250

lunar spa a part lunar prospector with

79

00:03:49,610 --> 00:03:46,979

an array of instruments observe the moon

80

00:03:52,430 --> 00:03:49,620

in its polar orbit and found something

81

00:03:55,939 --> 00:03:52,440

startling and that startling measurement

82

00:03:57,830 --> 00:03:55,949

was from the neutron spectrometer what

83

00:04:00,500 --> 00:03:57,840

it was measuring were neutrons that were

84

00:04:02,899 --> 00:04:00,510

being emitted by the moon caused by

85

00:04:06,189 --> 00:04:02,909

cosmic rays that penetrate its surface

86

00:04:08,780 --> 00:04:06,199

generating these neutrons but over

87

00:04:11,059 --> 00:04:08,790

permanently shadowed areas in the

88

00:04:14,689 --> 00:04:11,069

northern and southern hemisphere the

89

00:04:16,879 --> 00:04:14,699

neutron flux dropped significantly now

90

00:04:19,960 --> 00:04:16,889

one of the absorbers of neutrons has

91

00:04:25,010 --> 00:04:19,970

been known for some time and it's water

92

00:04:27,080 --> 00:04:25,020

so therefore at the end of the 90s and

93

00:04:30,290 --> 00:04:27,090

as we move into this new

94

00:04:33,950 --> 00:04:30,300

the generally thinking idea is that the

95

00:04:36,740 --> 00:04:33,960

moon is bone dry but there may be water

96

00:04:38,960 --> 00:04:36,750

at some amount in these print ly

97

00:04:42,230 --> 00:04:38,970

shadowed regions in the North and South

98

00:04:46,370 --> 00:04:42,240

Pole well what we're going to talk about

99

00:04:48,710 --> 00:04:46,380

today is truly a major advancement in

100

00:04:52,159 --> 00:04:48,720

our knowledge of the water content on

101  
00:04:55,490 --> 00:04:52,169  
the surface of the Moon three papers

102  
00:04:58,670 --> 00:04:55,500  
will be published in science today that

103  
00:05:01,909 --> 00:04:58,680  
will illustrate an enhanced knowledge of

104  
00:05:04,790 --> 00:05:01,919  
the percentage of water that exists all

105  
00:05:07,370 --> 00:05:04,800  
over the moon and not just in these

106  
00:05:09,560 --> 00:05:07,380  
permanently shadowed craters in fact the

107  
00:05:11,540 --> 00:05:09,570  
observations of today we will not be

108  
00:05:13,940 --> 00:05:11,550  
able to comment on how much water is in

109  
00:05:17,210 --> 00:05:13,950  
those craters because we can only

110  
00:05:21,500 --> 00:05:17,220  
measure from these instruments the light

111  
00:05:23,629 --> 00:05:21,510  
that comes back from the moon these new

112  
00:05:26,300 --> 00:05:23,639  
observations that will be reported here

113  
00:05:28,159 --> 00:05:26,310

are from three major instruments the

114

00:05:31,580 --> 00:05:28,169

instruments are the moon mineralogy

115

00:05:34,940 --> 00:05:31,590

mapper or M cubed this is on

116

00:05:37,430 --> 00:05:34,950

chandrayaan-1 second instrument is the

117

00:05:42,409 --> 00:05:37,440

visual and infrared mapping spectrometer

118

00:05:44,050 --> 00:05:42,419

or VIMS on the Cassini mission the third

119

00:05:49,100 --> 00:05:44,060

instrument is the high resolution

120

00:05:52,850 --> 00:05:49,110

infrared imaging spectrometer or HR I is

121

00:05:55,159 --> 00:05:52,860

on the Deep Impact which has gone into

122

00:05:57,740 --> 00:05:55,169

an extended mission and is referred to

123

00:06:00,790 --> 00:05:57,750

as many as epoxy but it's the same

124

00:06:04,070 --> 00:06:00,800

spacecraft now these high-resolution

125

00:06:08,180 --> 00:06:04,080

imaging spectrometers make it possible

126  
00:06:11,330 --> 00:06:08,190  
to map the lunar hydrogen content on the

127  
00:06:13,040 --> 00:06:11,340  
surface as never before possible the

128  
00:06:15,110 --> 00:06:13,050  
measurements from all three instruments

129  
00:06:18,020 --> 00:06:15,120  
I think you'll find by the end of

130  
00:06:21,589 --> 00:06:18,030  
today's conference as being quite clear

131  
00:06:23,180 --> 00:06:21,599  
we're critical in confirming the

132  
00:06:27,589 --> 00:06:23,190  
findings that we're going to talk about

133  
00:06:30,290 --> 00:06:27,599  
today now before I get started before we

134  
00:06:33,620 --> 00:06:30,300  
get started I want to take this time to

135  
00:06:37,370 --> 00:06:33,630  
especially thank the Indian Space

136  
00:06:40,430 --> 00:06:37,380  
Research Organization Israel that is the

137  
00:06:43,370 --> 00:06:40,440  
Indian Space Agency

138  
00:06:47,150 --> 00:06:43,380

for the partnership and collaboration

139

00:06:50,870 --> 00:06:47,160

with NASA that is made Chandra m and M

140

00:06:53,390 --> 00:06:50,880

cubed possible Israel shares in the

141

00:06:56,480 --> 00:06:53,400

credit the observations and finds that

142

00:06:58,340 --> 00:06:56,490

we will discuss today we are delighted

143

00:07:03,800 --> 00:06:58,350

that they are here represented by mr.

144

00:07:05,900 --> 00:07:03,810

Carnac from Israel welcome and without

145

00:07:10,190 --> 00:07:05,910

further ado I'd like to turn it over now

146

00:07:13,550 --> 00:07:10,200

to dr. Carly Peters mq principal

147

00:07:19,160 --> 00:07:13,560

scientist thank you Jim while the moon

148

00:07:20,900 --> 00:07:19,170

continues to surprise us and that's the

149

00:07:24,950 --> 00:07:20,910

message that I hope you will will take

150

00:07:28,900 --> 00:07:24,960

home with you today widespread water has

151  
00:07:31,340 --> 00:07:28,910  
been detected on the surface of the Moon

152  
00:07:33,530 --> 00:07:31,350  
you have to think outside of the box on

153  
00:07:37,220 --> 00:07:33,540  
this this is not what any of us expected

154  
00:07:40,630 --> 00:07:37,230  
a decade ago but widespread water has

155  
00:07:44,930 --> 00:07:40,640  
been detected on the surface of the Moon

156  
00:07:46,580 --> 00:07:44,940  
so we could have my first chart I'm

157  
00:07:48,290 --> 00:07:46,590  
going to be talking about the M cube

158  
00:07:51,409 --> 00:07:48,300  
results and giving you a quick overview

159  
00:07:55,060 --> 00:07:51,419  
of what they are and a few highlights of

160  
00:07:57,800 --> 00:07:55,070  
what we've seen this particular figure

161  
00:07:59,960 --> 00:07:57,810  
summarizes the observations acquired

162  
00:08:04,010 --> 00:07:59,970  
during what we call the first optical

163  
00:08:05,390 --> 00:08:04,020

period of the Shawn Regan operation for

164

00:08:06,650 --> 00:08:05,400

the near Side of the Moon the part of

165

00:08:08,530 --> 00:08:06,660

the moon that you're all familiar with

166

00:08:11,480 --> 00:08:08,540

when you go outside and look at the moon

167

00:08:15,680 --> 00:08:11,490

it illustrates the distribution of

168

00:08:19,520 --> 00:08:15,690

several highly diagnostic spectral

169

00:08:22,640 --> 00:08:19,530

properties the blue tones in this

170

00:08:25,520 --> 00:08:22,650

particular image illustrate where we

171

00:08:28,610 --> 00:08:25,530

have observed with the M cube geometry

172

00:08:32,420 --> 00:08:28,620

the distribution of the surface on the

173

00:08:37,100 --> 00:08:32,430

surface of h<sub>2</sub>o and o.h water and

174

00:08:40,279 --> 00:08:37,110

hydroxyl the green and red tones and the

175

00:08:41,990 --> 00:08:40,289

variations amongst them are in this

176

00:08:44,630 --> 00:08:42,000

particular image are designed to

177

00:08:47,300 --> 00:08:44,640

illustrate the location of a variety of

178

00:08:49,910 --> 00:08:47,310

mineral species across the surface of

179

00:08:52,880 --> 00:08:49,920

the Moon which is what the instrument

180

00:08:53,240 --> 00:08:52,890

was specifically designed to detect and

181

00:08:56,060 --> 00:08:53,250

math

182

00:08:58,550 --> 00:08:56,070

we will not spend much time on that part

183

00:09:02,330 --> 00:08:58,560

will concentrate on the detection of

184

00:09:06,140 --> 00:09:02,340

water near the high latitudes in this

185

00:09:09,110 --> 00:09:06,150

particular image let's go on to my next

186

00:09:11,630 --> 00:09:09,120

chart because what I need to explain to

187

00:09:14,780 --> 00:09:11,640

you right from the beginning is how we

188

00:09:17,450 --> 00:09:14,790

detect and why we are so certain that

189

00:09:21,140 --> 00:09:17,460

what we're looking at is water and

190

00:09:23,480 --> 00:09:21,150

hydroxyl on the moon we use a variety of

191

00:09:24,890 --> 00:09:23,490

spectrometers the one on m cube and the

192

00:09:26,870 --> 00:09:24,900

one on the other two instruments that

193

00:09:28,820 --> 00:09:26,880

you'll be hearing about to look at

194

00:09:31,870 --> 00:09:28,830

radiation that's reflected from the

195

00:09:35,230 --> 00:09:31,880

surface and measured with these various

196

00:09:37,670 --> 00:09:35,240

detectors its measured as a function of

197

00:09:41,240 --> 00:09:37,680

brightness as a function of wavelength

198

00:09:43,640 --> 00:09:41,250

or color in this particular chart over

199

00:09:45,920 --> 00:09:43,650

on the left is you can see right up at

200

00:09:48,470 --> 00:09:45,930

the top where the visible part of the

201  
00:09:53,150 --> 00:09:48,480  
spectrum occurs where your your eyes can

202  
00:09:54,800 --> 00:09:53,160  
tell the color of the surface moving to

203  
00:09:57,320 --> 00:09:54,810  
longer wavelengths or into the

204  
00:10:00,140 --> 00:09:57,330  
near-infrared you see a variety of

205  
00:10:02,650 --> 00:10:00,150  
highly diagnostic features that are due

206  
00:10:05,300 --> 00:10:02,660  
to the various minerals on the surface

207  
00:10:07,670 --> 00:10:05,310  
highlighted over on the left-hand part

208  
00:10:10,850 --> 00:10:07,680  
of this chart is the blow-up of the area

209  
00:10:12,920 --> 00:10:10,860  
that's uniquely diagnostic of o H and

210  
00:10:14,420 --> 00:10:12,930  
water on the surface of the Moon and

211  
00:10:17,540 --> 00:10:14,430  
I've identified in this particular

212  
00:10:20,840 --> 00:10:17,550  
figure where you see the diagnostic

213  
00:10:23,690 --> 00:10:20,850

absorptions of  $O_2$  +  $H_2O$  as well as the

214

00:10:26,060 --> 00:10:23,700

solid form of ice on the surface of the

215

00:10:29,450 --> 00:10:26,070

moon and we'll all be coming back to

216

00:10:32,120 --> 00:10:29,460

this fingerprint this highly diagnostic

217

00:10:35,180 --> 00:10:32,130

signature of detecting water on the

218

00:10:38,570 --> 00:10:35,190

surface of the moon okay let's move on

219

00:10:40,490 --> 00:10:38,580

to my next chart what shown here is

220

00:10:43,220 --> 00:10:40,500

again a summary of the  $M^3$  data

221

00:10:44,570 --> 00:10:43,230

shown on the Left labeled albedo is

222

00:10:46,730 --> 00:10:44,580

essentially the brightness of the

223

00:10:49,810 --> 00:10:46,740

surface of the moon as you would go out

224

00:10:52,280 --> 00:10:49,820

and look at it on a lovely moonlit night

225

00:10:54,710 --> 00:10:52,290

that gives you an orientation that you

226

00:10:57,170 --> 00:10:54,720

should be quite familiar with shown on

227

00:11:00,770 --> 00:10:57,180

the right is the distribution of the

228

00:11:04,100 --> 00:11:00,780

signature of  $O\ H$  and  $H\ 2\ O$  that  $M$  cube

229

00:11:07,280 --> 00:11:04,110

has detected you can see that in that

230

00:11:09,379 --> 00:11:07,290

particular this rendition of our

231

00:11:12,079 --> 00:11:09,389

detection is principally at the cooler

232

00:11:14,900 --> 00:11:12,089

areas of the moon namely the higher

233

00:11:16,670 --> 00:11:14,910

latitudes that's because of the geometry

234

00:11:19,249 --> 00:11:16,680

of our measurements are typically when

235

00:11:21,889 --> 00:11:19,259

the Sun is high and the only cool parts

236

00:11:23,780 --> 00:11:21,899

of the Moon are at high latitudes you

237

00:11:25,879 --> 00:11:23,790

may also be able to see that in the

238

00:11:28,579 --> 00:11:25,889

center of the northern area is a

239

00:11:30,050 --> 00:11:28,589

relatively bright area and what that

240

00:11:33,050 --> 00:11:30,060

shows you is that their spatial

241

00:11:35,870 --> 00:11:33,060

variability some areas have a stronger

242

00:11:38,329 --> 00:11:35,880

signature than other areas and we'll be

243

00:11:40,790 --> 00:11:38,339

coming back to that through the

244

00:11:43,970 --> 00:11:40,800

discussion so there's two take home

245

00:11:46,730 --> 00:11:43,980

messages here 1 M cube detects it at

246

00:11:49,189 --> 00:11:46,740

high latitudes and to their spatial

247

00:11:51,379 --> 00:11:49,199

variability and that one area that you

248

00:11:54,199 --> 00:11:51,389

see in the northern part is a large

249

00:11:56,749 --> 00:11:54,209

crater called Goldschmidt so we see it

250

00:12:01,490 --> 00:11:56,759

at large craters let's go to my next

251  
00:12:03,499 --> 00:12:01,500  
chart in addition to the large chart now

252  
00:12:06,710 --> 00:12:03,509  
we're all the previous data I'd shown

253  
00:12:09,680 --> 00:12:06,720  
you are we've taken our data and down

254  
00:12:11,569 --> 00:12:09,690  
sampled it a hundred times to fit onto

255  
00:12:13,610 --> 00:12:11,579  
one globe when you look at the

256  
00:12:16,850 --> 00:12:13,620  
individual measurements you see a lot

257  
00:12:20,780 --> 00:12:16,860  
more detail and this particular strip is

258  
00:12:24,230 --> 00:12:20,790  
40 kilometers in diameter and looking at

259  
00:12:27,290 --> 00:12:24,240  
very very small tiny fresh impact

260  
00:12:29,930 --> 00:12:27,300  
craters we see this signature shown over

261  
00:12:32,750 --> 00:12:29,940  
on the right this downturn into the

262  
00:12:35,000 --> 00:12:32,760  
diagnostic properties absorption

263  
00:12:37,069 --> 00:12:35,010

properties of water and what we're

264

00:12:39,620 --> 00:12:37,079

showing here is that even at small

265

00:12:41,769 --> 00:12:39,630

creators the size of meteor crater for

266

00:12:45,740 --> 00:12:41,779

example in Arizona you get this

267

00:12:48,079 --> 00:12:45,750

detection of the strong signal now also

268

00:12:51,350 --> 00:12:48,089

shown there perhaps less clear in the

269

00:12:53,780 --> 00:12:51,360

back of the room is the background area

270

00:12:55,460 --> 00:12:53,790

seen in this moon which does not have

271

00:12:58,850 --> 00:12:55,470

this signature so the spatial

272

00:13:03,530 --> 00:12:58,860

variability is very important ok let's

273

00:13:06,439 --> 00:13:03,540

go on to the next chart and what this

274

00:13:08,300 --> 00:13:06,449

shows is a variety of hypotheses that we

275

00:13:11,329 --> 00:13:08,310

and the various team members have been

276

00:13:14,389 --> 00:13:11,339

discussing of how what physical form

277

00:13:18,139 --> 00:13:14,399

this water may occur on the surface we

278

00:13:20,960 --> 00:13:18,149

do not know precisely we have several

279

00:13:23,679 --> 00:13:20,970

hypotheses we need of course more data

280

00:13:27,199 --> 00:13:23,689

but there's a lot of suggestions in fact

281

00:13:29,269 --> 00:13:27,209

one that we have a firm consensus on

282

00:13:31,850 --> 00:13:29,279

that what we're seeing occurs in the

283

00:13:35,210 --> 00:13:31,860

uppermost surface of the moon of the

284

00:13:37,280 --> 00:13:35,220

lunar soil upper two millimeters and

285

00:13:39,410 --> 00:13:37,290

these are variety of different ways that

286

00:13:40,730 --> 00:13:39,420

could occur it could occur as one mono

287

00:13:43,429 --> 00:13:40,740

layer where these are just a few

288

00:13:46,699 --> 00:13:43,439

molecules thick it could be mixed into

289

00:13:48,110 --> 00:13:46,709

the soil it could be altered minerals on

290

00:13:49,970 --> 00:13:48,120

the surface there could be various

291

00:13:52,129 --> 00:13:49,980

gradients within the upper few

292

00:13:55,189 --> 00:13:52,139

millimeters these are areas that will be

293

00:13:56,780 --> 00:13:55,199

actively pursuing in the years ahead and

294

00:13:58,999 --> 00:13:56,790

with that introduction let me turn it

295

00:14:00,559 --> 00:13:59,009

over to rob green Thank You Carly I'd

296

00:14:02,210 --> 00:14:00,569

like to provide at this point a little

297

00:14:05,059 --> 00:14:02,220

bit more background on the M cubed

298

00:14:08,300 --> 00:14:05,069

science mission and how we've come here

299

00:14:09,619 --> 00:14:08,310

M cube was designed and proposed to

300

00:14:11,600 --> 00:14:09,629

measure the composition of the moon

301  
00:14:14,210 --> 00:14:11,610  
you're seeing that here in this graphic

302  
00:14:16,129 --> 00:14:14,220  
we know the moon consists of rocks and

303  
00:14:18,110 --> 00:14:16,139  
rocks contain minerals on the upper

304  
00:14:20,179 --> 00:14:18,120  
right I've got a picture of a rock that

305  
00:14:23,150 --> 00:14:20,189  
was returned by the Apollo 15 mission

306  
00:14:24,639 --> 00:14:23,160  
the minerals in the rocks interact with

307  
00:14:27,079 --> 00:14:24,649  
light differently at different

308  
00:14:29,629 --> 00:14:27,089  
wavelengths and in the middle you're

309  
00:14:31,850 --> 00:14:29,639  
seeing spectral signatures so this is

310  
00:14:34,189 --> 00:14:31,860  
the way those minerals interact with the

311  
00:14:36,049 --> 00:14:34,199  
light through wavelengths and they give

312  
00:14:38,600 --> 00:14:36,059  
us signatures for us to decide what the

313  
00:14:40,759 --> 00:14:38,610

composition of the surface of the moon

314

00:14:42,710 --> 00:14:40,769

is based on these measurements so we

315

00:14:44,269 --> 00:14:42,720

needed an instrument that could measure

316

00:14:46,639 --> 00:14:44,279

the surface of the Moon and for every

317

00:14:48,470 --> 00:14:46,649

point in the images acquired we have a

318

00:14:50,660 --> 00:14:48,480

spectrum to get the signature to

319

00:14:54,170 --> 00:14:50,670

determine the composition could I have

320

00:14:56,240 --> 00:14:54,180

the next graphic please and this is a

321

00:14:59,470 --> 00:14:56,250

depiction of the type of instrument

322

00:15:02,360 --> 00:14:59,480

we've used with M cubed to achieve these

323

00:15:04,819 --> 00:15:02,370

amazing results from this graphic you

324

00:15:06,829 --> 00:15:04,829

can see white light is reflected from

325

00:15:09,079 --> 00:15:06,839

the moon into a telescope of our

326

00:15:11,509 --> 00:15:09,089

instrument from that telescope the light

327

00:15:14,150 --> 00:15:11,519

is passed into a spectrometer we break

328

00:15:16,040 --> 00:15:14,160

the natural light into the rainbow into

329

00:15:17,960 --> 00:15:16,050

the spectrum and then record that

330

00:15:20,809 --> 00:15:17,970

spectrum for each point in the image

331

00:15:22,549 --> 00:15:20,819

producing an image cube which contains a

332

00:15:24,439 --> 00:15:22,559

spectral signature for each point in the

333

00:15:27,590 --> 00:15:24,449

image from which we can determine the

334

00:15:30,889 --> 00:15:27,600

composition of the surface next graphic

335

00:15:34,530 --> 00:15:30,899

please and this is the instrument a very

336

00:15:36,570 --> 00:15:34,540

special instrument the M cubed develop

337

00:15:38,430 --> 00:15:36,580

at the Jet Propulsion Laboratory here we

338

00:15:39,930 --> 00:15:38,440

are in the clean room during the

339

00:15:42,660 --> 00:15:39,940

development process this gives you an

340

00:15:44,250 --> 00:15:42,670

idea of its size Carly Peters the

341

00:15:46,290 --> 00:15:44,260

principal scientist is there with their

342

00:15:48,960 --> 00:15:46,300

hand out looking at the instrument

343

00:15:50,670 --> 00:15:48,970

during the alignment phase just to give

344

00:15:53,730 --> 00:15:50,680

you a perspective the instrument weighs

345

00:15:57,030 --> 00:15:53,740

about 20 pounds it runs with the energy

346

00:15:59,940 --> 00:15:57,040

of a 20 watt light bulb and is about the

347

00:16:01,620 --> 00:15:59,950

size of a desktop laser printer to give

348

00:16:03,360 --> 00:16:01,630

you a feel for what it is and it's quite

349

00:16:06,450 --> 00:16:03,370

a compact little instrument for a very

350

00:16:09,050 --> 00:16:06,460

big job which is to map the composition

351  
00:16:12,090 --> 00:16:09,060  
of the entire surface of Earth's moon

352  
00:16:14,460 --> 00:16:12,100  
could I have the next graphic please and

353  
00:16:16,050 --> 00:16:14,470  
now I'd like to show you some more of

354  
00:16:18,480 --> 00:16:16,060  
the spectacular results that have been

355  
00:16:20,070 --> 00:16:18,490  
returned by M cubed the image on the

356  
00:16:21,840 --> 00:16:20,080  
left is one of our very favorites this

357  
00:16:24,060 --> 00:16:21,850  
is one of the first images that came

358  
00:16:26,400 --> 00:16:24,070  
back on the 19th of november two

359  
00:16:28,110 --> 00:16:26,410  
thousand eight which showed us on the

360  
00:16:29,910 --> 00:16:28,120  
chandran went one mission we had a

361  
00:16:31,680 --> 00:16:29,920  
working instrument and we were measuring

362  
00:16:34,200 --> 00:16:31,690  
exactly we set out to measure which were

363  
00:16:36,090 --> 00:16:34,210

spectral image cubes where we have an

364

00:16:38,100 --> 00:16:36,100

image and then for every point of that

365

00:16:40,800 --> 00:16:38,110

image we have a spectrum underlying it

366

00:16:42,420 --> 00:16:40,810

to measure the composition of the

367

00:16:44,100 --> 00:16:42,430

surface of the Moon and you're seeing a

368

00:16:47,670 --> 00:16:44,110

representation of those spectra on the

369

00:16:50,700 --> 00:16:47,680

top and side rainbow panels so we were

370

00:16:52,650 --> 00:16:50,710

very excited to see this this result on

371

00:16:54,600 --> 00:16:52,660

the 19th of November I've included

372

00:16:57,060 --> 00:16:54,610

another image cube there this is another

373

00:16:59,490 --> 00:16:57,070

spectacular dataset collected this is

374

00:17:01,290 --> 00:16:59,500

the Apollo 15 landing site and you can

375

00:17:04,890 --> 00:17:01,300

see the Hadley real there where the

376

00:17:07,430 --> 00:17:04,900

Apollo 15 landed decades ago and I want

377

00:17:10,260 --> 00:17:07,440

to summarize that we have in fact almost

378

00:17:13,260 --> 00:17:10,270

1,000 gigabytes of data from M cube

379

00:17:15,690 --> 00:17:13,270

returned over 10 months all of this type

380

00:17:17,220 --> 00:17:15,700

to allow us to in fact cover more than

381

00:17:18,930 --> 00:17:17,230

ninety percent of the moon and you're

382

00:17:20,790 --> 00:17:18,940

just seeing the beginning of the results

383

00:17:23,520 --> 00:17:20,800

and some of the highlights from the

384

00:17:26,430 --> 00:17:23,530

early analysis of these data so could I

385

00:17:28,080 --> 00:17:26,440

have the next graphic please so having

386

00:17:30,390 --> 00:17:28,090

shown you some of the data sets now I'd

387

00:17:33,960 --> 00:17:30,400

like to show some of the mineral results

388

00:17:36,300 --> 00:17:33,970

from M cube this is a map of aspects of

389

00:17:38,700 --> 00:17:36,310

the mineralogy of Earth's moon here

390

00:17:41,520 --> 00:17:38,710

you're seeing in greens purples and

391

00:17:43,080 --> 00:17:41,530

blues iron-bearing minerals that we've

392

00:17:45,450 --> 00:17:43,090

been able to map because we have a

393

00:17:47,919 --> 00:17:45,460

spectral signature for every point in

394

00:17:49,749 --> 00:17:47,929

the image that we've collected these

395

00:17:52,090 --> 00:17:49,759

the iron minerals that would be similar

396

00:17:54,430 --> 00:17:52,100

to the basalt lavas that you might find

397

00:17:57,549 --> 00:17:54,440

in the Hawaiian volcanoes for example

398

00:17:59,710 --> 00:17:57,559

the red areas are areas that contain the

399

00:18:02,560 --> 00:17:59,720

mineral pelagic case again plagioclase

400

00:18:04,570 --> 00:18:02,570

we're measuring minerals and these are

401

00:18:07,029 --> 00:18:04,580

pledged place is a feldspar mineral

402

00:18:09,100 --> 00:18:07,039

which is also found in earth rocks it's

403

00:18:10,899 --> 00:18:09,110

a common rock-forming minerals so just

404

00:18:12,460 --> 00:18:10,909

to give you an indication that we're

405

00:18:14,739 --> 00:18:12,470

also proceeding in addition to the

406

00:18:16,690 --> 00:18:14,749

amazing water discovery we've also begun

407

00:18:19,389 --> 00:18:16,700

our primary mission of mapping the

408

00:18:21,489 --> 00:18:19,399

mineralogy averse moon with these data

409

00:18:23,859 --> 00:18:21,499

and now before I go to the next slide

410

00:18:25,810 --> 00:18:23,869

I'd like to invite you all tonight or

411

00:18:27,669 --> 00:18:25,820

over the next week if it's clear to go

412

00:18:30,639 --> 00:18:27,679

out and look at the moon as you've known

413

00:18:33,070 --> 00:18:30,649

it I've known it as a white or grey

414

00:18:35,710 --> 00:18:33,080

object in the sky and to realize that

415

00:18:37,330 --> 00:18:35,720

with an imaging spectrometer like M

416

00:18:39,879 --> 00:18:37,340

cubed like the other instruments will be

417

00:18:42,039 --> 00:18:39,889

talking about really it's the moon is

418

00:18:44,320 --> 00:18:42,049

much more than simply a grey body in

419

00:18:47,830 --> 00:18:44,330

orbit around the earth it is full of a

420

00:18:50,289 --> 00:18:47,840

spectacular spectral variation and this

421

00:18:53,320 --> 00:18:50,299

depiction should shift to a movie

422

00:18:54,879 --> 00:18:53,330

through the spectrum showing the

423

00:18:57,310 --> 00:18:54,889

different colors that we've been able to

424

00:18:59,440 --> 00:18:57,320

derive their you can start to see colors

425

00:19:02,799 --> 00:18:59,450

sweep through this is a tour through the

426

00:19:05,169 --> 00:19:02,809

M cubed dataset collected so far showing

427

00:19:07,269 --> 00:19:05,179

the the amazing compositional diversity

428

00:19:09,850 --> 00:19:07,279

for all of those who thought the moon

429

00:19:12,909 --> 00:19:09,860

was gray it isn't it's full of

430

00:19:15,279 --> 00:19:12,919

spectacular spectral content which we

431

00:19:16,720 --> 00:19:15,289

can relate to composition we've talked a

432

00:19:18,519 --> 00:19:16,730

little bit about the water that we've

433

00:19:20,499 --> 00:19:18,529

discovered with these measurements and a

434

00:19:22,539 --> 00:19:20,509

little bit about the mineralogy but

435

00:19:24,879 --> 00:19:22,549

we're going to know in the next decades

436

00:19:26,320 --> 00:19:24,889

much more about the moon thanks to these

437

00:19:29,379 --> 00:19:26,330

measurements and with that I'd like to

438

00:19:32,080 --> 00:19:29,389

pass it to Roger okay I'm going to talk

439

00:19:35,259 --> 00:19:32,090

about the Cassini results and also more

440

00:19:38,470 --> 00:19:35,269

M cube results Cassini flew by the earth

441

00:19:40,779 --> 00:19:38,480

and got a view of the moon on its on a

442

00:19:43,749 --> 00:19:40,789

gravity assist on its way to Saturn back

443

00:19:48,029 --> 00:19:43,759

in August of 1999 so it's been a long

444

00:19:51,070 --> 00:19:48,039

time and the first slide please the

445

00:19:53,230 --> 00:19:51,080

basic results of the Cassini flyby of

446

00:19:56,470 --> 00:19:53,240

the Moon are shown here in the top or

447

00:19:58,720 --> 00:19:56,480

just a normal intensity view from the

448

00:20:00,789 --> 00:19:58,730

VINs instrument and the imaging system

449

00:20:01,600 --> 00:20:00,799

and in the bottom row are the derived

450

00:20:04,299 --> 00:20:01,610

results

451

00:20:07,390 --> 00:20:04,309

the VINs the temperature in the middle

452

00:20:09,910 --> 00:20:07,400

is the map of the water and on the lower

453

00:20:12,940 --> 00:20:09,920

right is the map of the hydroxyl now

454

00:20:15,820 --> 00:20:12,950

what's astounding about these results is

455

00:20:18,039 --> 00:20:15,830

that the water and hydroxyl exists at

456

00:20:20,680 --> 00:20:18,049

all latitudes on the moon in direct

457

00:20:23,110 --> 00:20:20,690

sunlight where it's a really quite hot

458

00:20:29,500 --> 00:20:23,120

in fact hütter at the equator than

459

00:20:34,330 --> 00:20:29,510

boiling water so now the hydroxyl is an

460

00:20:36,820 --> 00:20:34,340

o H molecule or bond that creates a

461

00:20:38,500 --> 00:20:36,830

chemical reaction with other minerals in

462

00:20:40,930 --> 00:20:38,510

the surface and that will create

463

00:20:42,970 --> 00:20:40,940

hydroxyl bearing minerals we haven't

464

00:20:45,580 --> 00:20:42,980

identified the any of the minerals yet

465

00:20:47,409 --> 00:20:45,590

but there's a wide variety of hydroxyl

466

00:20:52,150 --> 00:20:47,419

bearing compounds clay minerals are an

467

00:20:54,340 --> 00:20:52,160

example of hydroxyl bearing minerals now

468

00:20:57,430 --> 00:20:54,350

the diversity that we see here there's

469

00:20:59,020 --> 00:20:57,440

variations in the intensity of the the

470

00:21:01,360 --> 00:20:59,030

water signature and the hydroxyl

471

00:21:03,880 --> 00:21:01,370

signature that's telling us that there's

472

00:21:06,220 --> 00:21:03,890

some dynamic processes going on the

473

00:21:07,690 --> 00:21:06,230

weathering and reactions going on are

474

00:21:09,750 --> 00:21:07,700

different on different places on the

475

00:21:13,659 --> 00:21:09,760

moon let's go to the next view graph

476  
00:21:15,580 --> 00:21:13,669  
where I'll show you why this is a pretty

477  
00:21:18,370 --> 00:21:15,590  
difficult detection and why it takes

478  
00:21:20,799 --> 00:21:18,380  
three spacecraft to really confirm it

479  
00:21:23,350 --> 00:21:20,809  
and make it a solid detection so that

480  
00:21:25,990 --> 00:21:23,360  
all many scientists will believe the

481  
00:21:29,169 --> 00:21:26,000  
result first the amount of water is

482  
00:21:30,700 --> 00:21:29,179  
small so we're only our best estimate

483  
00:21:34,409 --> 00:21:30,710  
right now for the amount of water is

484  
00:21:37,900 --> 00:21:34,419  
about a ton or liter of water per a

485  
00:21:40,510 --> 00:21:37,910  
about a quart or liter of water per ton

486  
00:21:42,700 --> 00:21:40,520  
of lunar material and that's lunar

487  
00:21:44,530 --> 00:21:42,710  
material in the top part of the the

488  
00:21:48,400 --> 00:21:44,540

surface the top couple of millimeters

489

00:21:50,110 --> 00:21:48,410

the detection results in a very small

490

00:21:54,039 --> 00:21:50,120

absorption band that is shown here in

491

00:21:56,350 --> 00:21:54,049

gray on this graph and you see results

492

00:21:58,960 --> 00:21:56,360

from two instruments the MQ band and

493

00:22:01,330 --> 00:21:58,970

vims give very close to the same answer

494

00:22:03,430 --> 00:22:01,340

which is what we were looking for to

495

00:22:06,640 --> 00:22:03,440

verify that the calibration is accurate

496

00:22:08,950 --> 00:22:06,650

between the instruments further the M

497

00:22:10,590 --> 00:22:08,960

cube doesn't go as far out in wavelength

498

00:22:13,510 --> 00:22:10,600

as the VINs or the deep impact

499

00:22:15,370 --> 00:22:13,520

spacecraft does so the VINs and Deep

500

00:22:18,730 --> 00:22:15,380

Impact can see water

501  
00:22:21,100 --> 00:22:18,740  
in hotter places then is easy for the MQ

502  
00:22:24,150 --> 00:22:21,110  
instrument to see it we will continue

503  
00:22:26,830 --> 00:22:24,160  
work with the M cube data to try and

504  
00:22:28,780 --> 00:22:26,840  
work on detecting water at lower

505  
00:22:33,070 --> 00:22:28,790  
latitudes but the VINs in the Deep

506  
00:22:34,480 --> 00:22:33,080  
Impact have an advantage here and you

507  
00:22:36,070 --> 00:22:34,490  
can see that we see more of the water

508  
00:22:37,990 --> 00:22:36,080  
band so we can better define it where

509  
00:22:40,360 --> 00:22:38,000  
the heat is coming out the moon is quite

510  
00:22:42,430 --> 00:22:40,370  
hot so these red dash lines on there are

511  
00:22:45,310 --> 00:22:42,440  
the thermal emission from the moon

512  
00:22:47,020 --> 00:22:45,320  
before we removed it from the spectra so

513  
00:22:49,120 --> 00:22:47,030

we have to remove the heat before we can

514

00:22:52,180 --> 00:22:49,130

see the water well especially at the

515

00:22:54,370 --> 00:22:52,190

lower latitudes now M cube however has

516

00:22:56,230 --> 00:22:54,380

an advantage and that it's orbiting the

517

00:22:58,360 --> 00:22:56,240

moon so if we can go to the next slide

518

00:23:01,060 --> 00:22:58,370

we'll look at some of the

519

00:23:03,040 --> 00:23:01,070

high-resolution data or the we've

520

00:23:06,220 --> 00:23:03,050

covered most of the moon at this kind of

521

00:23:09,010 --> 00:23:06,230

resolution 140 meters per pixel and this

522

00:23:12,040 --> 00:23:09,020

is a small crater on the far side that's

523

00:23:15,850 --> 00:23:12,050

on the right or left hand side of the

524

00:23:18,760 --> 00:23:15,860

image here and on the left is shown just

525

00:23:21,100 --> 00:23:18,770

the infrared intensity but on the the

526

00:23:24,490 --> 00:23:21,110

right is shown or derived water

527

00:23:26,860 --> 00:23:24,500

abundance so we see this this meteor has

528

00:23:29,680 --> 00:23:26,870

come in probably within the last hundred

529

00:23:32,410 --> 00:23:29,690

million years and exploded the surface

530

00:23:35,950 --> 00:23:32,420

and spewed that material out onto the

531

00:23:38,110 --> 00:23:35,960

surface and we see that with M cube as a

532

00:23:40,480 --> 00:23:38,120

water-rich ejecta blanket now that's

533

00:23:43,090 --> 00:23:40,490

only part of the story the the ejecta

534

00:23:45,130 --> 00:23:43,100

blanket and water rich nature of it goes

535

00:23:46,870 --> 00:23:45,140

in all directions but in the moment

536

00:23:48,940 --> 00:23:46,880

we're going to put on the hydroxyl and

537

00:23:51,280 --> 00:23:48,950

you'll see the hydroxyl doesn't go in

538

00:23:55,090 --> 00:23:51,290

all directions here well it just came up

539

00:23:57,280 --> 00:23:55,100

the hydroxyl comes out mainly at the one

540

00:24:01,200 --> 00:23:57,290

o'clock and seven o'clock position this

541

00:24:03,820 --> 00:24:01,210

is typical when a meteor comes in and it

542

00:24:05,620 --> 00:24:03,830

ejects material from the surface that is

543

00:24:07,570 --> 00:24:05,630

buried in the surface so if this

544

00:24:09,720 --> 00:24:07,580

interpretation is correct and we'll be

545

00:24:14,980 --> 00:24:09,730

studying this further this implies that

546

00:24:17,290 --> 00:24:14,990

these recently fresh or young craters

547

00:24:19,900 --> 00:24:17,300

have excavated water and hydroxyl rich

548

00:24:22,270 --> 00:24:19,910

material in the surface and that implies

549

00:24:24,700 --> 00:24:22,280

that there is areas around the moon

550

00:24:26,860 --> 00:24:24,710

where there's more water than just on

551

00:24:28,610 --> 00:24:26,870

the surface we see a lot of these

552

00:24:30,470 --> 00:24:28,620

craters Carly showed some other in

553

00:24:32,450 --> 00:24:30,480

tations of some even even smaller ones

554

00:24:34,880 --> 00:24:32,460

there are also craters that don't show

555

00:24:36,440 --> 00:24:34,890

this effect so there's a lot of

556

00:24:37,760 --> 00:24:36,450

different interpretations to do and we

557

00:24:40,190 --> 00:24:37,770

have a lot of work to do to go through

558

00:24:42,110 --> 00:24:40,200

the M cubed data and perhaps future

559

00:24:45,890 --> 00:24:42,120

missions and with that alternate over to

560

00:24:47,840 --> 00:24:45,900

Jessica thanks Roger I'm going to share

561

00:24:50,060 --> 00:24:47,850

with you the results from observations

562

00:24:54,170 --> 00:24:50,070

from the deep impact spacecraft since

563

00:24:56,360 --> 00:24:54,180

July 4th of 2005 and our successful

564

00:24:59,090 --> 00:24:56,370

impact experiment with the comet tempel

565

00:25:00,890 --> 00:24:59,100

1 well the deep impact team has been on

566

00:25:03,530 --> 00:25:00,900

an extended mission which will be

567

00:25:08,240 --> 00:25:03,540

culminating in just over a year from now

568

00:25:09,830 --> 00:25:08,250

in a flyby of the comet Hartley 2 along

569

00:25:13,520 --> 00:25:09,840

the way we've made several observations

570

00:25:15,169 --> 00:25:13,530

of the moon for calibration purposes and

571

00:25:17,810 --> 00:25:15,179

while our spectrometer was obviously

572

00:25:20,630 --> 00:25:17,820

designed for commentary observations it

573

00:25:23,210 --> 00:25:20,640

is ideally suited for measuring the o.h

574

00:25:25,910 --> 00:25:23,220

and h2o absorption features that you've

575

00:25:30,560 --> 00:25:25,920

heard described at three microns so if I

576

00:25:32,840 --> 00:25:30,570

could have my first graph please I in

577

00:25:36,230 --> 00:25:32,850

purple on the left you see the location

578

00:25:38,270 --> 00:25:36,240

of data that we collected in 2007 over

579

00:25:40,700 --> 00:25:38,280

the equator and then in blue of the

580

00:25:43,160 --> 00:25:40,710

northern polar regions that were

581

00:25:45,290 --> 00:25:43,170

collected this past June on the right

582

00:25:48,110 --> 00:25:45,300

you see the corresponding spectra and

583

00:25:51,620 --> 00:25:48,120

with the deep bet impact spectrometer we

584

00:25:53,690 --> 00:25:51,630

now unequivocally see the entire water

585

00:25:56,330 --> 00:25:53,700

and o.h absorption feature and that's

586

00:25:58,220 --> 00:25:56,340

the areas that are shaded the feature is

587

00:26:01,220 --> 00:25:58,230

relatively strong in the blue polar

588

00:26:03,320 --> 00:26:01,230

regions are whereas at the equator which

589

00:26:06,530 --> 00:26:03,330

is the data and purple which of course

590

00:26:09,500 --> 00:26:06,540

is much warmer there is still a distinct

591

00:26:12,140 --> 00:26:09,510

feature but it's much weaker now we can

592

00:26:13,910 --> 00:26:12,150

explore this variability in more detail

593

00:26:15,500 --> 00:26:13,920

looking at the full range of the data

594

00:26:17,500 --> 00:26:15,510

that was collected in june of this year

595

00:26:21,710 --> 00:26:17,510

and if i can have the next chart please

596

00:26:23,630 --> 00:26:21,720

on the left is a location image with

597

00:26:25,730 --> 00:26:23,640

Clementine data showing our vantage

598

00:26:28,640 --> 00:26:25,740

point looking at the northern polar

599

00:26:31,630 --> 00:26:28,650

regions right next to it is a the black

600

00:26:33,830 --> 00:26:31,640

and white brightness image which is

601  
00:26:37,070 --> 00:26:33,840  
constructed from the Deep Impact spectra

602  
00:26:39,050 --> 00:26:37,080  
it shows you the two basic lunar

603  
00:26:40,950 --> 00:26:39,060  
materials the right highlands and the

604  
00:26:43,139 --> 00:26:40,960  
dark of volcanic Mario

605  
00:26:46,320 --> 00:26:43,149  
I should point out that we took this

606  
00:26:48,510 --> 00:26:46,330  
data from a vantage point of 8 million

607  
00:26:50,610 --> 00:26:48,520  
kilometers away which is a little bit

608  
00:26:52,680 --> 00:26:50,620  
different than M cubed which had an

609  
00:26:55,409 --> 00:26:52,690  
advantage of spatial resolution because

610  
00:26:57,840 --> 00:26:55,419  
chandrayaan-1 was in a hundred kilometer

611  
00:27:01,500 --> 00:26:57,850  
orbit above the moon which makes a great

612  
00:27:03,210 --> 00:27:01,510  
comparative data set in orange you see

613  
00:27:06,330 --> 00:27:03,220

the temperature map that we derive from

614

00:27:07,710 --> 00:27:06,340

our data not surprisingly you can see

615

00:27:10,889 --> 00:27:07,720

that its warmest on the right because

616

00:27:13,700 --> 00:27:10,899

that's where the Sun is once we remove

617

00:27:16,230 --> 00:27:13,710

these thermal effects as Roger explained

618

00:27:18,659 --> 00:27:16,240

we can then measure the overall strength

619

00:27:20,580 --> 00:27:18,669

of the absorption features and you can

620

00:27:22,320 --> 00:27:20,590

see there's significant variability in

621

00:27:26,490 --> 00:27:22,330

this water signature we have the

622

00:27:29,159 --> 00:27:26,500

strongest amounts of water on the left

623

00:27:30,960 --> 00:27:29,169

in red and the weakest on the right in

624

00:27:33,330 --> 00:27:30,970

blue and if you look at all three of

625

00:27:35,700 --> 00:27:33,340

these images together you can see that

626

00:27:38,549 --> 00:27:35,710

the water signature is not correlated to

627

00:27:41,760 --> 00:27:38,559

brightness it's not correlated to the

628

00:27:45,600 --> 00:27:41,770

terrain types but it is very correlated

629

00:27:48,810 --> 00:27:45,610

to temperature so if I could have the

630

00:27:51,240 --> 00:27:48,820

next graphic please it turns out that we

631

00:27:53,789 --> 00:27:51,250

were very lucky in June because we

632

00:27:56,220 --> 00:27:53,799

happen to take observations twice on the

633

00:27:58,799 --> 00:27:56,230

second and the ninth and in that one

634

00:28:00,840 --> 00:27:58,809

week of terrestrial time which is a

635

00:28:04,200 --> 00:28:00,850

quarter of a day on the moon the moon

636

00:28:06,419 --> 00:28:04,210

rotated 90 degrees and this allows us to

637

00:28:09,000 --> 00:28:06,429

look at the strength of the absorption

638

00:28:11,250 --> 00:28:09,010

features as a function of time of day so

639

00:28:14,190 --> 00:28:11,260

for example in the upper left you'll see

640

00:28:16,440 --> 00:28:14,200

a dark Mari region labeled M which is in

641

00:28:20,220 --> 00:28:16,450

the morning on jun 2nd it has just

642

00:28:22,740 --> 00:28:20,230

rotated into sunlight but on jun 9th on

643

00:28:26,700 --> 00:28:22,750

the lower left you can see that it is a

644

00:28:28,169 --> 00:28:26,710

near local loon similarly we can look at

645

00:28:31,080 --> 00:28:28,179

one of the highland units which are

646

00:28:34,289 --> 00:28:31,090

labeled in h the in black and h they

647

00:28:36,870 --> 00:28:34,299

started on jun 2nd at noon but by the

648

00:28:40,200 --> 00:28:36,880

ninth have now almost rotated out of

649

00:28:41,909 --> 00:28:40,210

sunlight and are in the evening and if

650

00:28:44,190 --> 00:28:41,919

we look at the spectral properties for

651

00:28:46,710 --> 00:28:44,200

example of this highlands unit we find

652

00:28:49,289 --> 00:28:46,720

some interesting results at noon shown

653

00:28:52,289 --> 00:28:49,299

in red and the on the right plot the

654

00:28:53,490 --> 00:28:52,299

absorption is relatively weak but in the

655

00:28:57,300 --> 00:28:53,500

evening we have a much strong

656

00:28:58,590 --> 00:28:57,310

3 micron absorption and there's also

657

00:29:01,080 --> 00:28:58,600

actually a difference in the change in

658

00:29:02,310 --> 00:29:01,090

shape and what we found we looked at all

659

00:29:05,490 --> 00:29:02,320

of our data was a very systematic

660

00:29:07,860 --> 00:29:05,500

pattern where we had strong absorptions

661

00:29:09,600 --> 00:29:07,870

in the morning they weakened as we

662

00:29:12,150 --> 00:29:09,610

approach noon and then increased again

663

00:29:14,280 --> 00:29:12,160

in the afternoon and finally by evening

664

00:29:15,690 --> 00:29:14,290

had returned to the same steady state

665

00:29:19,440 --> 00:29:15,700

that they started with in the morning

666

00:29:23,850 --> 00:29:19,450

and so the important point here is that

667

00:29:27,840 --> 00:29:23,860

we're seeing an entire cycle of loss and

668

00:29:29,610 --> 00:29:27,850

recovery of water features that's in

669

00:29:32,730 --> 00:29:29,620

current that's occurring during the

670

00:29:33,990 --> 00:29:32,740

daytime and in the next slide I'll try

671

00:29:37,290 --> 00:29:34,000

to give at least one explanation for

672

00:29:40,650 --> 00:29:37,300

what might be going on this is as a

673

00:29:44,700 --> 00:29:40,660

schematic illustrating just one possible

674

00:29:46,320 --> 00:29:44,710

explanation of our observations during

675

00:29:48,650 --> 00:29:46,330

the daytime the moon is exposed to the

676

00:29:51,360 --> 00:29:48,660

solar wind which includes hydrogen ions

677

00:29:53,400 --> 00:29:51,370

so if you look on the lower left in the

678

00:29:57,060 --> 00:29:53,410

morning which is relatively cold the

679

00:29:58,950 --> 00:29:57,070

blue in the green areas the hydrogen

680

00:30:02,250 --> 00:29:58,960

ions are able to interact with the

681

00:30:05,670 --> 00:30:02,260

oxygen of the lunar soil to form an

682

00:30:07,980 --> 00:30:05,680

accumulate  $\text{O}_2$  and  $\text{H}_2\text{O}$  molecules by noon

683

00:30:10,560 --> 00:30:07,990

in the center where the moon is its

684

00:30:13,800 --> 00:30:10,570

warmest the red areas are their

685

00:30:15,660 --> 00:30:13,810

significant water loss then as the moon

686

00:30:17,880 --> 00:30:15,670

cools down towards evening it's able to

687

00:30:21,540 --> 00:30:17,890

once again interact with the solar wind

688

00:30:23,400 --> 00:30:21,550

and accumulate water and h<sub>2</sub>o molecules

689

00:30:27,750 --> 00:30:23,410

and we end up at the same place that we

690

00:30:30,510 --> 00:30:27,760

started in the morning this cycle means

691

00:30:32,280 --> 00:30:30,520

a number of things one of which is that

692

00:30:34,500 --> 00:30:32,290

regardless of the location or the

693

00:30:36,870 --> 00:30:34,510

terrain type the entire surface de Lune

694

00:30:41,070 --> 00:30:36,880

will be hydrated during during at least

695

00:30:44,430 --> 00:30:41,080

part of the lunar day I'd also like to

696

00:30:46,200 --> 00:30:44,440

note that if this is actually the

697

00:30:47,790 --> 00:30:46,210

explanation for the water signature that

698

00:30:51,120 --> 00:30:47,800

we've all been talking about and it may

699

00:30:53,970 --> 00:30:51,130

not be but if it is this same process

700

00:30:56,310 --> 00:30:53,980

would cause the similar hydration

701  
00:30:59,340 --> 00:30:56,320  
effects throughout the own inner solar

702  
00:31:00,990 --> 00:30:59,350  
system on any oxygen rich body that

703  
00:31:03,390 --> 00:31:01,000  
doesn't have an atmosphere and that

704  
00:31:05,880 --> 00:31:03,400  
would include for example mercury and

705  
00:31:07,500 --> 00:31:05,890  
many asteroids and with that I'll pass

706  
00:31:11,010 --> 00:31:07,510  
it back to Jim thank you very much

707  
00:31:12,780 --> 00:31:11,020  
Jessica so as you can see there's a new

708  
00:31:15,690 --> 00:31:12,790  
dimension in the water story about the

709  
00:31:18,600 --> 00:31:15,700  
moon we've discussed things that aren't

710  
00:31:22,050 --> 00:31:18,610  
in permanently shadowed craters however

711  
00:31:24,660 --> 00:31:22,060  
we find that there are a number of

712  
00:31:26,610 --> 00:31:24,670  
important scientific results that we

713  
00:31:29,370 --> 00:31:26,620

need to make sure get stated

714

00:31:32,750 --> 00:31:29,380

appropriately so the takeaway message is

715

00:31:36,510 --> 00:31:32,760

this the observations presented here

716

00:31:40,440 --> 00:31:36,520

show a combination of hydroxyl o-h and

717

00:31:42,540 --> 00:31:40,450

h<sub>2</sub>o that resides in the upper millimeter

718

00:31:45,480 --> 00:31:42,550

or a few millimetres of the lunar

719

00:31:48,000 --> 00:31:45,490

surface the average amount of water

720

00:31:51,240 --> 00:31:48,010

reported if we were to extract it is

721

00:31:56,160 --> 00:31:51,250

about as Roger mentioned a quart of

722

00:31:58,530 --> 00:31:56,170

water per ton so as another analogy for

723

00:32:04,320 --> 00:31:58,540

a thousand pounds that would be 16

724

00:32:07,830 --> 00:32:04,330

ounces of water also as I mentioned for

725

00:32:10,470 --> 00:32:07,840

a thousand pounds of the equator that

726

00:32:13,130 --> 00:32:10,480

would be 2t tablespoons of water as

727

00:32:15,930 --> 00:32:13,140

observed from the Apollo perspective

728

00:32:18,210 --> 00:32:15,940

from a scientific perspective the

729

00:32:20,250 --> 00:32:18,220

difference between the northern regions

730

00:32:23,310 --> 00:32:20,260

with this amount of water and the

731

00:32:25,320 --> 00:32:23,320

equatorial regions are truly astounding

732

00:32:28,560 --> 00:32:25,330

and are generating much scientific

733

00:32:32,970 --> 00:32:28,570

excitement however please keep this in

734

00:32:35,790 --> 00:32:32,980

mind that even the driest deserts in the

735

00:32:38,160 --> 00:32:35,800

earth have more water than are at the

736

00:32:42,060 --> 00:32:38,170

poles and the surfaces as we've

737

00:32:44,700 --> 00:32:42,070

presented here of the moon currently

738

00:32:48,270 --> 00:32:44,710

there are no complete explanations for

739

00:32:50,669 --> 00:32:48,280

this phenomena and I'm sure the

740

00:32:52,410 --> 00:32:50,679

observations from M cubed and other

741

00:32:54,600 --> 00:32:52,420

spacecraft in the next several years

742

00:32:56,310 --> 00:32:54,610

will continue to bring out more

743

00:32:59,160 --> 00:32:56,320

questions that need to be answered about

744

00:33:02,190 --> 00:32:59,170

this phenomenon and this will be studied

745

00:33:04,950 --> 00:33:02,200

for many years to come and with that

746

00:33:05,730 --> 00:33:04,960

doing thank you all okay what we're

747

00:33:07,860 --> 00:33:05,740

going to do we're going to offer

748

00:33:09,750 --> 00:33:07,870

questions and we have a number of media

749

00:33:11,640 --> 00:33:09,760

on the phone line so we'll go to the

750

00:33:14,250 --> 00:33:11,650

Ames Research Center and then we'll take

751

00:33:17,230 --> 00:33:14,260

calls on the phone line so we will go

752

00:33:24,380 --> 00:33:20,720

hi this is a Mike Swift reporter with

753

00:33:27,110 --> 00:33:24,390

the San Jose Mercury News the el cross

754

00:33:30,440 --> 00:33:27,120

spacecraft is uh scheduled to impact the

755

00:33:32,600 --> 00:33:30,450

moon on october 9th i believe um what

756

00:33:35,390 --> 00:33:32,610

more do you expect to learn from that

757

00:33:38,000 --> 00:33:35,400

mission in terms of either the quantity

758

00:33:41,630 --> 00:33:38,010

or the state of water in the polar

759

00:33:44,990 --> 00:33:41,640

regions of the moon given me finding

760

00:33:47,570 --> 00:33:45,000

this is dwayne we have with us our

761

00:33:50,570 --> 00:33:47,580

exploration officials so we're going to

762

00:33:53,810 --> 00:33:50,580

give them the mic and identify yourself

763

00:33:55,430 --> 00:33:53,820

and can respond to that please yeah i'm

764

00:33:57,850 --> 00:33:55,440

michael wacha and the chief lunar

765

00:34:00,049 --> 00:33:57,860

scientists for exploration systems and

766

00:34:03,200 --> 00:34:00,059

we're really excited about the results

767

00:34:06,380 --> 00:34:03,210

that we're hearing today and as the

768

00:34:09,710 --> 00:34:06,390

question indicated we're conducting an

769

00:34:12,710 --> 00:34:09,720

experiment on october 9th that will look

770

00:34:14,750 --> 00:34:12,720

at the potential for water and one of

771

00:34:17,690 --> 00:34:14,760

the permanently shadowed craters on the

772

00:34:20,750 --> 00:34:17,700

moon South Pole one of the differences

773

00:34:21,980 --> 00:34:20,760

though is that the way in which week

774

00:34:25,129 --> 00:34:21,990

we're going to be conducting that

775

00:34:27,589 --> 00:34:25,139

experiment is it's going to excavate the

776

00:34:30,409 --> 00:34:27,599

lunar surface go through that upper

777

00:34:33,680 --> 00:34:30,419

surface and down on the order of a meter

778

00:34:37,099 --> 00:34:33,690

or so to look at the potential

779

00:34:40,760 --> 00:34:37,109

distribution of water ice and other

780

00:34:43,220 --> 00:34:40,770

volatile in the upper meter or two of

781

00:34:45,680 --> 00:34:43,230

the of the lunar surface so different

782

00:34:50,180 --> 00:34:45,690

kind of question that were that we're

783

00:34:51,889 --> 00:34:50,190

answering and the water question for the

784

00:34:54,800 --> 00:34:51,899

moon is a complex one I think we're

785

00:34:58,490 --> 00:34:54,810

hearing that today and just because

786

00:35:00,680 --> 00:34:58,500

there is water at the surface at the mid

787

00:35:02,660 --> 00:35:00,690

and high latitudes doesn't mean that it

788

00:35:05,599 --> 00:35:02,670

can't exist as water ice in the

789

00:35:08,510 --> 00:35:05,609

permanently shadowed regions in fact we

790

00:35:09,950 --> 00:35:08,520

heard today was a potential explanation

791

00:35:12,170 --> 00:35:09,960

for how the water gets into those

792

00:35:15,650 --> 00:35:12,180

permanently shadowed regions so these

793

00:35:18,070 --> 00:35:15,660

are really complementary experiments

794

00:35:20,480 --> 00:35:18,080

that are being done and it shows how

795

00:35:23,570 --> 00:35:20,490

exploration enables science and science

796

00:35:26,660 --> 00:35:23,580

enables exploration here so a NASA

797

00:35:28,880 --> 00:35:26,670

together is moving forward on the on

798

00:35:30,140 --> 00:35:28,890

helping to answer the water question for

799

00:35:31,370 --> 00:35:30,150

the moon thank you

800

00:35:34,730 --> 00:35:31,380

I are we going to go to the phone lines

801  
00:35:40,519 --> 00:35:34,740  
now and we have Clara from space com

802  
00:35:42,589 --> 00:35:40,529  
Sarah hi I was hoping you could talk a

803  
00:35:44,990 --> 00:35:42,599  
little bit more about series for the

804  
00:35:47,569 --> 00:35:45,000  
origin of this water does the recent

805  
00:35:50,480 --> 00:35:47,579  
findings indicate more that the solar

806  
00:35:56,750 --> 00:35:50,490  
wind origin might be a better idea than

807  
00:36:00,260 --> 00:35:56,760  
cometary impacts I can address this this

808  
00:36:02,990 --> 00:36:00,270  
is Roger Clarke I don't think so at this

809  
00:36:05,329 --> 00:36:03,000  
point I mean there's many models out

810  
00:36:08,180 --> 00:36:05,339  
there and probably to some degree they

811  
00:36:09,980 --> 00:36:08,190  
all are in in play and it's more a

812  
00:36:12,829 --> 00:36:09,990  
matter of working out what the

813  
00:36:16,279 --> 00:36:12,839

proportions are so yeah it's too early

814

00:36:17,720 --> 00:36:16,289

to tell maybe it's likely there won't

815

00:36:19,569 --> 00:36:17,730

this Robert Greene it's likely there

816

00:36:24,349 --> 00:36:19,579

will not just be a single mechanism and

817

00:36:28,569 --> 00:36:24,359

just to echo what Roger is saying okay

818

00:36:34,329 --> 00:36:28,579

well now go to Keith Cowen on the phone

819

00:36:39,019 --> 00:36:36,650

question you have had two other space

820

00:36:41,750 --> 00:36:39,029

went by the room making observations one

821

00:36:43,370 --> 00:36:41,760

in November of 2008 and another way back

822

00:36:45,289 --> 00:36:43,380

in nineteen ninety nine given that

823

00:36:48,049 --> 00:36:45,299

you're treating both of these as being

824

00:36:50,289 --> 00:36:48,059

cooperative to the or recent data why

825

00:36:52,880 --> 00:36:50,299

wasn't at least the information from

826

00:36:55,539 --> 00:36:52,890

Deep Impact published to released to the

827

00:36:58,220 --> 00:36:55,549

public why did you sit on this through

828

00:37:03,410 --> 00:36:58,230

this is I see Annalise is most certainly

829

00:37:05,450 --> 00:37:03,420

my any information or not he's back in

830

00:37:06,710 --> 00:37:05,460

nineteen ninety nine or tooth out let me

831

00:37:09,349 --> 00:37:06,720

start with deep impact I don't have

832

00:37:11,480 --> 00:37:09,359

Roger talk about times daily he broke up

833

00:37:13,789 --> 00:37:11,490

so much please restate a quick i think

834

00:37:16,099 --> 00:37:13,799

that Shore answer i think he was asking

835

00:37:18,500 --> 00:37:16,109

that why given that some of the deep

836

00:37:21,500 --> 00:37:18,510

impact data dates back to 2007 and the

837

00:37:24,049 --> 00:37:21,510

cassini database packs in 1999 haven't

838

00:37:26,420 --> 00:37:24,059

we been talking about it before the

839

00:37:29,180 --> 00:37:26,430

answer for deep impact is that in the

840

00:37:31,789 --> 00:37:29,190

data we collected at 2007 was over the

841

00:37:34,359 --> 00:37:31,799

equator and as you saw it's an extremely

842

00:37:36,620 --> 00:37:34,369

weak feature we weren't looking at it

843

00:37:39,620 --> 00:37:36,630

for anything but calibration purposes

844

00:37:41,530 --> 00:37:39,630

and it wasn't until after we actually

845

00:37:44,150 --> 00:37:41,540

recalibrated the instrument with them

846

00:37:46,160 --> 00:37:44,160

2009 data which remember we took for

847

00:37:47,720 --> 00:37:46,170

calibration purposes that were able to

848

00:37:50,510 --> 00:37:47,730

go back and see that very weak feature

849

00:37:53,600 --> 00:37:50,520

in 2007 which is a long way of saying is

850

00:37:54,710 --> 00:37:53,610

we didn't know it until very recently in

851  
00:37:57,440 --> 00:37:54,720  
fact it was the last thing that was

852  
00:37:59,960 --> 00:37:57,450  
added to the paper now what Roger amps

853  
00:38:02,660 --> 00:37:59,970  
for crostini okay Cassini flew by the

854  
00:38:04,760 --> 00:38:02,670  
earth in August 99 to do a gravity

855  
00:38:07,430 --> 00:38:04,770  
assist we were able to turn on the

856  
00:38:09,230 --> 00:38:07,440  
spacecraft for a brief time to acquire

857  
00:38:11,870 --> 00:38:09,240  
data as we went by the moon and in fact

858  
00:38:14,750 --> 00:38:11,880  
we also intended it for calibration

859  
00:38:17,930 --> 00:38:14,760  
purposes but we had no other calibration

860  
00:38:21,410 --> 00:38:17,940  
data until we were approaching Saturn in

861  
00:38:23,570 --> 00:38:21,420  
2004 when we started our looks at stars

862  
00:38:26,360 --> 00:38:23,580  
and we also have a solar port so we're

863  
00:38:29,660 --> 00:38:26,370

looking at the Sun every spacecraft that

864

00:38:31,340 --> 00:38:29,670

is launched from the earth when it's

865

00:38:32,920 --> 00:38:31,350

made in the lab there's so much water

866

00:38:35,870 --> 00:38:32,930

around the earth and water is such a

867

00:38:38,270 --> 00:38:35,880

sticky molecule that it sticks to all

868

00:38:39,980 --> 00:38:38,280

the surfaces so every spacecraft that's

869

00:38:42,650 --> 00:38:39,990

out there right now at the moment has

870

00:38:45,260 --> 00:38:42,660

water all over the spacecraft sticking

871

00:38:47,120 --> 00:38:45,270

to it and spectrometers can see that and

872

00:38:49,160 --> 00:38:47,130

it's a quite a challenge to calibrate

873

00:38:52,340 --> 00:38:49,170

the spectrometers so we're not seeing

874

00:38:55,580 --> 00:38:52,350

water everywhere so it took from 2004

875

00:38:59,050 --> 00:38:55,590

through 2008 to acquire the data on

876

00:39:01,010 --> 00:38:59,060

Cassini to calibrate out the the

877

00:39:03,380 --> 00:39:01,020

signatures of water we were actually

878

00:39:04,970 --> 00:39:03,390

seeing stars with water in them which we

879

00:39:07,190 --> 00:39:04,980

knew was not correct and we traced it

880

00:39:09,860 --> 00:39:07,200

down to the calibration of the

881

00:39:11,990 --> 00:39:09,870

instrument and so it wasn't until last

882

00:39:13,970 --> 00:39:12,000

summer that the calibration was good

883

00:39:16,070 --> 00:39:13,980

enough and the first papers with this

884

00:39:19,160 --> 00:39:16,080

new calibration or have been submitted

885

00:39:22,340 --> 00:39:19,170

only starting in January so it's really

886

00:39:24,050 --> 00:39:22,350

been a calibration issue okay the next

887

00:39:33,140 --> 00:39:24,060

question is from andrea thompson from

888

00:39:36,140 --> 00:39:33,150

space com how it's thought that this

889

00:39:37,490 --> 00:39:36,150

water might sort of be mobile and moved

890

00:39:40,490 --> 00:39:37,500

to the polls and I'm not sure I quite

891

00:39:41,600 --> 00:39:40,500

understand how that might work could you

892

00:39:45,830 --> 00:39:41,610

repeat the first part of your question

893

00:39:47,570 --> 00:39:45,840

again please oh yeah sorry I was

894

00:39:49,820 --> 00:39:47,580

wondering if you could explain the how

895

00:39:51,470 --> 00:39:49,830

you think that the water molecules are

896

00:39:52,260 --> 00:39:51,480

mobile and how they might be moving to

897

00:39:58,500 --> 00:39:52,270

the pole that

898

00:40:01,050 --> 00:39:58,510

quite get how that would work I'm sure

899

00:40:02,250 --> 00:40:01,060

I'll take a stab at this um this is one

900

00:40:06,870 --> 00:40:02,260

of the questions that we would like to

901  
00:40:10,020 --> 00:40:06,880  
have addressed as well as you've seen

902  
00:40:11,880 --> 00:40:10,030  
this is an entirely new phenomena that

903  
00:40:14,940 --> 00:40:11,890  
has not been studied in great detail

904  
00:40:18,360 --> 00:40:14,950  
until we had conclusive evidence that it

905  
00:40:20,250 --> 00:40:18,370  
even existed some of the things we do

906  
00:40:25,140 --> 00:40:20,260  
not know is what is the relative

907  
00:40:28,230 --> 00:40:25,150  
proportion of water and hydroxyl we have

908  
00:40:30,810 --> 00:40:28,240  
very strong indications that some of

909  
00:40:33,240 --> 00:40:30,820  
this is time varying both in the M cube

910  
00:40:35,370 --> 00:40:33,250  
data and the Deep Impact data but we

911  
00:40:37,890 --> 00:40:35,380  
don't know in what way it's varying is

912  
00:40:40,350 --> 00:40:37,900  
it mobile or is it being created and

913  
00:40:42,570 --> 00:40:40,360

destroyed on a rapid manner we simply do

914

00:40:45,210 --> 00:40:42,580

not know these issues it's intriguing

915

00:40:47,790 --> 00:40:45,220

and we certainly want to go back and try

916

00:40:49,890 --> 00:40:47,800

to identify what is needed to address

917

00:40:52,740 --> 00:40:49,900

those very questions we have to

918

00:40:55,680 --> 00:40:52,750

understand the physics of this silicate

919

00:41:00,870 --> 00:40:55,690

surface and the vacuum around it which

920

00:41:03,240 --> 00:41:00,880

is awash with solar wind particles micro

921

00:41:05,820 --> 00:41:03,250

meteorites this is an environment and

922

00:41:09,110 --> 00:41:05,830

interface that we know very little about

923

00:41:11,940 --> 00:41:09,120

and the physics is just in its infancy

924

00:41:14,580 --> 00:41:11,950

well I can address a little more on that

925

00:41:17,120 --> 00:41:14,590

this phenomenon is actually observed a

926

00:41:20,580 --> 00:41:17,130

couple of places in the solar system

927

00:41:22,380 --> 00:41:20,590

basically the idea is that where it's

928

00:41:24,570 --> 00:41:22,390

hot water molecules will tend to

929

00:41:26,370 --> 00:41:24,580

evaporate and gravity they'll fly off

930

00:41:28,440 --> 00:41:26,380

the surface and gravity will pull them

931

00:41:30,420 --> 00:41:28,450

back down so they're the molecules are

932

00:41:32,700 --> 00:41:30,430

hopping around if they're not swept away

933

00:41:35,010 --> 00:41:32,710

by a magnetic field or solar wind or

934

00:41:37,770 --> 00:41:35,020

something so where it's colder the

935

00:41:39,720 --> 00:41:37,780

molecules will stick longer so as the

936

00:41:41,220 --> 00:41:39,730

molecules bounce around when it gets to

937

00:41:44,990 --> 00:41:41,230

the cold polar regions they'll stay

938

00:41:47,280 --> 00:41:45,000

there we observe a frost buildup on

939

00:41:49,470 --> 00:41:47,290

satellite of Jupiter Ganymede now

940

00:41:54,210 --> 00:41:49,480

Voyager got some very nice pictures of

941

00:41:56,400 --> 00:41:54,220

those the saturn moon iapetus has a very

942

00:41:58,380 --> 00:41:56,410

dark hemisphere and it looks like water

943

00:42:01,550 --> 00:41:58,390

has migrated to the poles so we see this

944

00:42:04,980 --> 00:42:01,560

kind of migration in on other body so

945

00:42:07,020 --> 00:42:04,990

it's just a surprise to see it

946

00:42:08,960 --> 00:42:07,030

working at the moon Anna I would like to

947

00:42:11,460 --> 00:42:08,970

have this is jessica sun shining that um

948

00:42:13,109 --> 00:42:11,470

it's just a hypothesis that it's

949

00:42:15,330 --> 00:42:13,119

migrating we have no evidence of that

950

00:42:17,190 --> 00:42:15,340

it's very well unknown one of the

951

00:42:19,140 --> 00:42:17,200

variables we didn't talk about is that

952

00:42:21,660 --> 00:42:19,150

water photo dissociates very quickly

953

00:42:23,940 --> 00:42:21,670

certainly within the terrestrial day on

954

00:42:25,230 --> 00:42:23,950

the moon and so there's a lot of what

955

00:42:26,940 --> 00:42:25,240

you're hearing here is basically there's

956

00:42:29,040 --> 00:42:26,950

a lot of unknowns that we need to work

957

00:42:31,830 --> 00:42:29,050

out to try to explain what I think is a

958

00:42:33,390 --> 00:42:31,840

tremendous set of observations there are

959

00:42:34,980 --> 00:42:33,400

many more that Rob green there are many

960

00:42:37,080 --> 00:42:34,990

more questions to date and we had six

961

00:42:39,840 --> 00:42:37,090

months ago and and there's going to be a

962

00:42:41,910 --> 00:42:39,850

lot of work as jim has said over years

963

00:42:45,270 --> 00:42:41,920

and probably decades understanding this

964

00:42:47,760 --> 00:42:45,280

phenomena and following up on it the

965

00:42:51,990 --> 00:42:47,770

next call is from ken Kramer for us from

966

00:42:54,000 --> 00:42:52,000

space flight magazine Kim ah hi thank

967

00:42:55,380 --> 00:42:54,010

you very much for taking my call yes I

968

00:42:57,720 --> 00:42:55,390

wonder if you could describe a little

969

00:43:00,120 --> 00:42:57,730

bit more the mechanism of this water

970

00:43:03,420 --> 00:43:00,130

formation by the solar wind are you

971

00:43:05,910 --> 00:43:03,430

conducting any lab experiments and was

972

00:43:08,580 --> 00:43:05,920

this hypothesized before you got this

973

00:43:12,120 --> 00:43:08,590

data at all and a second question is

974

00:43:18,990 --> 00:43:12,130

there any what is the follow up with LR

975

00:43:21,480 --> 00:43:19,000

0 and deep impact thank you says you

976  
00:43:22,980 --> 00:43:21,490  
want to i'm certainly not doing any lab

977  
00:43:25,140 --> 00:43:22,990  
work yet we haven't had time I don't

978  
00:43:27,210 --> 00:43:25,150  
know about you the rest of you guys at

979  
00:43:28,620 --> 00:43:27,220  
we just said I think most of the first

980  
00:43:31,170 --> 00:43:28,630  
question which is we don't really know

981  
00:43:33,180 --> 00:43:31,180  
what's going on yet and by we we mean

982  
00:43:34,920 --> 00:43:33,190  
the broad community and we certainly

983  
00:43:37,790 --> 00:43:34,930  
need more expertise than sitting in

984  
00:43:40,980 --> 00:43:37,800  
front of you to answer these questions

985  
00:43:43,080 --> 00:43:40,990  
to answer your GV m cut deep impact

986  
00:43:45,599 --> 00:43:43,090  
question we have sadly made our last

987  
00:43:47,880 --> 00:43:45,609  
observation of the moon after we've done

988  
00:43:50,040 --> 00:43:47,890

our last gravity assist happily that's

989

00:43:52,950 --> 00:43:50,050

put us towards our primary target

990

00:43:57,780 --> 00:43:52,960

Hartley 2 but we will be able to do any

991

00:44:02,099 --> 00:43:57,790

more observations here hydrogen has been

992

00:44:04,200 --> 00:44:02,109

found to come off the Apollo samples and

993

00:44:07,770 --> 00:44:04,210

it has solar wind has been hypothesized

994

00:44:11,609 --> 00:44:07,780

to be trapped in in the lunar regolith

995

00:44:13,830 --> 00:44:11,619

so in the soil so you know we expect at

996

00:44:17,460 --> 00:44:13,840

least some of the signal to be due to

997

00:44:18,840 --> 00:44:17,470

that effect next question is from

998

00:44:25,440 --> 00:44:18,850

Charles rotli it

999

00:44:28,590 --> 00:44:25,450

examiner.com Charles hello tell fredley

1000

00:44:31,950 --> 00:44:28,600

I'm interested in the diurnal variation

1001  
00:44:34,530 --> 00:44:31,960  
that was observed by deep impact the

1002  
00:44:36,530 --> 00:44:34,540  
lower absorption during the day and the

1003  
00:44:39,000 --> 00:44:36,540  
higher absorption of the dawn and dusk

1004  
00:44:41,490 --> 00:44:39,010  
have you noticed any difference between

1005  
00:44:45,180 --> 00:44:41,500  
the dawn and dusk side and night

1006  
00:44:47,670 --> 00:44:45,190  
indicate if the accumulation is

1007  
00:44:49,470 --> 00:44:47,680  
continuously in the 14 de Luna night you

1008  
00:44:52,650 --> 00:44:49,480  
might expect to see more on the door

1009  
00:44:56,310 --> 00:44:52,660  
inside right uh that's a very good

1010  
00:44:57,780 --> 00:44:56,320  
question the answer is we within our

1011  
00:45:00,750 --> 00:44:57,790  
detectability we don't see a difference

1012  
00:45:02,460 --> 00:45:00,760  
between morning and evening we don't see

1013  
00:45:04,320 --> 00:45:02,470

an accumulation at night which you might

1014

00:45:07,800 --> 00:45:04,330

expect if condensation was going on for

1015

00:45:09,390 --> 00:45:07,810

example ah and that is what drove us to

1016

00:45:13,140 --> 00:45:09,400

this concept that we had a cycle that

1017

00:45:14,550 --> 00:45:13,150

was going on during the day okay we're

1018

00:45:16,590 --> 00:45:14,560

gonna come back to NASA headquarters

1019

00:45:19,470 --> 00:45:16,600

with a question sir can you give your

1020

00:45:21,720 --> 00:45:19,480

name and affiliation and John Mulligan

1021

00:45:24,450 --> 00:45:21,730

from the Providence Journal for dr.

1022

00:45:26,550 --> 00:45:24,460

Peters I wonder if you could take us

1023

00:45:29,760 --> 00:45:26,560

back to November and relive for us the

1024

00:45:32,190 --> 00:45:29,770

moment when this information began to

1025

00:45:33,930 --> 00:45:32,200

arrive where were you and what were you

1026  
00:45:37,100 --> 00:45:33,940  
doing how long did it take to apprehend

1027  
00:45:42,450 --> 00:45:37,110  
what was happening what did you feel

1028  
00:45:45,840 --> 00:45:42,460  
there's a lot in that question actually

1029  
00:45:48,240 --> 00:45:45,850  
both Rob and I were at in banglore when

1030  
00:45:51,780 --> 00:45:48,250  
the data first started arriving and when

1031  
00:45:54,210 --> 00:45:51,790  
we saw the first image we were elated uh

1032  
00:45:56,220 --> 00:45:54,220  
were tears in her eyes we saw that first

1033  
00:45:59,700 --> 00:45:56,230  
image come back it's a long ride and

1034  
00:46:04,340 --> 00:45:59,710  
then through the 10 months the data have

1035  
00:46:13,260 --> 00:46:04,350  
been acquired obviously the Israel

1036  
00:46:16,530 --> 00:46:13,270  
operations played a incredibly a crucial

1037  
00:46:19,050 --> 00:46:16,540  
role in carrying out this successfully

1038  
00:46:20,730 --> 00:46:19,060

but we do as Rob had mentioned I have

1039

00:46:22,770 --> 00:46:20,740

ninety percent of the surface of the

1040

00:46:26,340 --> 00:46:22,780

Moon covered at the kind of resolutions

1041

00:46:30,600 --> 00:46:26,350

that you were looking at today getting

1042

00:46:32,760 --> 00:46:30,610

back to the water itself when the mq

1043

00:46:35,790 --> 00:46:32,770

team first saw

1044

00:46:39,000 --> 00:46:35,800

this signal in our data we like most

1045

00:46:41,400 --> 00:46:39,010

other teams before us had immediately

1046

00:46:45,210 --> 00:46:41,410

assumed oh this is calibration it's not

1047

00:46:47,130 --> 00:46:45,220

possible the moon doesn't do this but as

1048

00:46:50,430 --> 00:46:47,140

we discuss further and when Roger

1049

00:46:55,770 --> 00:46:50,440

brought in the vims data to to to show

1050

00:46:58,730 --> 00:46:55,780

us it became clear as the M cube data

1051  
00:47:00,810 --> 00:46:58,740  
accumulated the vim data became stronger

1052  
00:47:03,960 --> 00:47:00,820  
this was something we could not ignore

1053  
00:47:07,890 --> 00:47:03,970  
and within our team we spent months

1054  
00:47:10,620 --> 00:47:07,900  
trying to find what was wrong i disprove

1055  
00:47:12,840 --> 00:47:10,630  
that I did disprove it clearly there

1056  
00:47:14,880 --> 00:47:12,850  
must be something we've overlooked we

1057  
00:47:17,580 --> 00:47:14,890  
tried everything and we could not find

1058  
00:47:21,470 --> 00:47:17,590  
anything wrong with either our data or

1059  
00:47:24,570 --> 00:47:21,480  
the VINs data and by that time we about

1060  
00:47:25,830 --> 00:47:24,580  
decided okay we should start really

1061  
00:47:29,070 --> 00:47:25,840  
start writing and prepare for

1062  
00:47:30,750 --> 00:47:29,080  
publication will still put a caveat in

1063  
00:47:33,570 --> 00:47:30,760

there because maybe there's something

1064

00:47:35,550 --> 00:47:33,580

that we just haven't thought about but

1065

00:47:38,270 --> 00:47:35,560

then Jessica reminded us well you know

1066

00:47:41,820 --> 00:47:38,280

deep impact is having this calibration a

1067

00:47:45,540 --> 00:47:41,830

flyby amen we'll be able to look at the

1068

00:47:48,600 --> 00:47:45,550

moon and okay so they did and Jessica

1069

00:47:51,650 --> 00:47:48,610

got the deep impact team to process that

1070

00:47:54,750 --> 00:47:51,660

date a real fast for this problem and

1071

00:47:56,970 --> 00:47:54,760

the rest is history now it is completely

1072

00:48:01,680 --> 00:47:56,980

conclusive there is no question

1073

00:48:04,050 --> 00:48:01,690

whatsoever um and here we are okay we

1074

00:48:06,090 --> 00:48:04,060

have time for maybe a question or two

1075

00:48:07,530 --> 00:48:06,100

we've got to reconfigure for another

1076

00:48:10,710 --> 00:48:07,540

event here so we're going to go back to

1077

00:48:17,070 --> 00:48:10,720

the phone line James Dean from Florida

1078

00:48:19,110 --> 00:48:17,080

today hi thanks other than as a resource

1079

00:48:20,010 --> 00:48:19,120

that astronauts might be able to use is

1080

00:48:22,200 --> 00:48:20,020

just wondering if you could speak a

1081

00:48:24,180 --> 00:48:22,210

little bit to the what the the key

1082

00:48:26,940 --> 00:48:24,190

implication of this is finding of more

1083

00:48:29,970 --> 00:48:26,950

widespread water is is it say something

1084

00:48:31,920 --> 00:48:29,980

about it more about the understand the

1085

00:48:33,690 --> 00:48:31,930

formation of the moon or just suggest

1086

00:48:37,140 --> 00:48:33,700

new possibilities for life and other

1087

00:48:40,650 --> 00:48:37,150

places we probably will have four

1088

00:48:43,370 --> 00:48:40,660

different answers to that let me let me

1089

00:48:46,249 --> 00:48:43,380

start out this is Carly

1090

00:48:50,079 --> 00:48:46,259

Oh first thing we need to know is what

1091

00:48:55,630 --> 00:48:50,089

the source of this this water and h2o is

1092

00:48:58,549 --> 00:48:55,640

is it solar wind is it comet is it

1093

00:49:00,920 --> 00:48:58,559

meteorites that have accumulate on is it

1094

00:49:04,009 --> 00:49:00,930

from the interior there is a possibility

1095

00:49:06,529 --> 00:49:04,019

that degassing from the interior from

1096

00:49:08,779 --> 00:49:06,539

time to time we simply don't know and

1097

00:49:10,880 --> 00:49:08,789

those are fundamental science questions

1098

00:49:16,759 --> 00:49:10,890

that we need to understand about this

1099

00:49:20,029 --> 00:49:16,769

silicate body yeah I think I'll let

1100

00:49:23,390 --> 00:49:20,039

Jessica pick up the next hi I think you

1101  
00:49:25,099 --> 00:49:23,400  
did a good job early ah but it does have

1102  
00:49:28,039 --> 00:49:25,109  
implications this is Jim Green as

1103  
00:49:29,690 --> 00:49:28,049  
Jessica mentioned in other thank nearly

1104  
00:49:32,839 --> 00:49:29,700  
airless bodies in our solar system

1105  
00:49:35,779 --> 00:49:32,849  
that's also quite exciting thank you yes

1106  
00:49:40,309 --> 00:49:35,789  
but it's also important because here's

1107  
00:49:42,920 --> 00:49:40,319  
an discovery of a couple of ways one

1108  
00:49:47,059 --> 00:49:42,930  
it's a method that we can use to find

1109  
00:49:49,599 --> 00:49:47,069  
water from orbit or on the ground with

1110  
00:49:52,970 --> 00:49:49,609  
Landers I mean astronauts can use

1111  
00:49:54,710 --> 00:49:52,980  
instruments like these Rovers all kinds

1112  
00:49:57,680 --> 00:49:54,720  
of instruments could be used to search

1113  
00:50:00,200 --> 00:49:57,690

for water in these hot environments do

1114

00:50:02,599 --> 00:50:00,210

probing of all kinds of things just not

1115

00:50:04,490 --> 00:50:02,609

just the moon all all instruments we do

1116

00:50:07,160 --> 00:50:04,500

have imaging spectrometers around a lot

1117

00:50:10,220 --> 00:50:07,170

of objects now but for the moon it's

1118

00:50:12,009 --> 00:50:10,230

important because before this press

1119

00:50:15,410 --> 00:50:12,019

conference and before our colleagues

1120

00:50:18,109 --> 00:50:15,420

have learned about our papers this was

1121

00:50:20,359 --> 00:50:18,119

thought to be impossible to have water

1122

00:50:22,549 --> 00:50:20,369

on the surface of the Moon in hot

1123

00:50:24,529 --> 00:50:22,559

sunlight you know especially at the

1124

00:50:27,230 --> 00:50:24,539

equator let alone the higher latitudes

1125

00:50:29,569 --> 00:50:27,240

so it's a really profound discovery

1126

00:50:32,240 --> 00:50:29,579

could I have a small addendum because I

1127

00:50:34,819 --> 00:50:32,250

just thought of another one and that is

1128

00:50:36,680 --> 00:50:34,829

that that most of us are geologists and

1129

00:50:39,559 --> 00:50:36,690

we get very excited about how planets

1130

00:50:41,359 --> 00:50:39,569

form and evolve but but this phenomenon

1131

00:50:45,170 --> 00:50:41,369

clearly has to be a marriage between

1132

00:50:46,910 --> 00:50:45,180

geology and space physics and and and

1133

00:50:49,039 --> 00:50:46,920

and this is going to be a really

1134

00:50:51,920 --> 00:50:49,049

productive interaction over the next few

1135

00:50:53,509 --> 00:50:51,930

years okay time for one more question on

1136

00:50:58,650 --> 00:50:53,519

the phone line Raphael Jaffe from

1137

00:51:06,130 --> 00:51:03,550

yes question I guess for Jim Green do I

1138

00:51:10,300 --> 00:51:06,140

understand correctly that mq is like a

1139

00:51:13,480 --> 00:51:10,310

passenger on an ndn of satellite that is

1140

00:51:17,320 --> 00:51:13,490

surveying the moon and the associated

1141

00:51:20,110 --> 00:51:17,330

one is is a similar instrument on nasa's

1142

00:51:24,940 --> 00:51:20,120

current lunar reconnaissance orbiter

1143

00:51:29,260 --> 00:51:24,950

which i believe is even now mapping the

1144

00:51:30,720 --> 00:51:29,270

moon and more detail yes i'll take part

1145

00:51:35,170 --> 00:51:30,730

of that question this is Jim Green

1146

00:51:37,180 --> 00:51:35,180

indeed nasa has opportunities that we

1147

00:51:39,730 --> 00:51:37,190

call missions of opportunity for which

1148

00:51:42,910 --> 00:51:39,740

individual investigators may propose and

1149

00:51:46,330 --> 00:51:42,920

if their proposal is scientifically the

1150

00:51:49,000 --> 00:51:46,340

best can be selected build those

1151

00:51:52,900 --> 00:51:49,010

instruments to fly on other agency

1152

00:51:56,770 --> 00:51:52,910

spacecraft and in so and indeed M cubed

1153

00:52:01,660 --> 00:51:56,780

is a guest instrument on the CH and Ryan

1154

00:52:04,600 --> 00:52:01,670

one spacecraft built by Israel in terms

1155

00:52:07,390 --> 00:52:04,610

of LR 0 that is an exploration systems

1156

00:52:13,210 --> 00:52:07,400

Mission Directorate mission and Mike

1157

00:52:15,910 --> 00:52:13,220

does does LRO have an M cubed well nASA

1158

00:52:17,500 --> 00:52:15,920

has an M cubed and of course we're going

1159

00:52:20,560 --> 00:52:17,510

to be taking advantage of all of the

1160

00:52:22,870 --> 00:52:20,570

data that's coming back the science

1161

00:52:26,020 --> 00:52:22,880

Mission Directorate invited me during

1162

00:52:28,210 --> 00:52:26,030

the review process to be looking at m2

1163

00:52:30,820 --> 00:52:28,220

for its value to exploration and that's

1164

00:52:33,570 --> 00:52:30,830

just perfectly clear on LRO we have

1165

00:52:36,370 --> 00:52:33,580

complimentary instruments that are also

1166

00:52:39,040 --> 00:52:36,380

addressing the is there water on the

1167

00:52:41,980 --> 00:52:39,050

moon question looking in different

1168

00:52:43,960 --> 00:52:41,990

wavelengths than the infrared and

1169

00:52:46,690 --> 00:52:43,970

far-infrared we have a lyman-alpha

1170

00:52:48,600 --> 00:52:46,700

mapper that looks at the complete other

1171

00:52:52,090 --> 00:52:48,610

end at the very short wavelengths

1172

00:52:54,760 --> 00:52:52,100

looking for a signature of a similar

1173

00:52:57,540 --> 00:52:54,770

type of absorption but for the for the

1174

00:53:00,670 --> 00:52:57,550

lower wavelengths additionally we have a

1175

00:53:03,370 --> 00:53:00,680

lunar exploration Neutron detector that

1176  
00:53:05,410 --> 00:53:03,380  
takes another step toward looking at

1177  
00:53:07,420 --> 00:53:05,420  
those low energy neutrons that's a

1178  
00:53:10,040 --> 00:53:07,430  
signature for hydrogen on the moon so

1179  
00:53:12,260 --> 00:53:10,050  
LRO is also going to be adding

1180  
00:53:15,260 --> 00:53:12,270  
the wealth of information about the moon

1181  
00:53:18,050 --> 00:53:15,270  
providing the best maps available and

1182  
00:53:21,080 --> 00:53:18,060  
also contributing to the to answering

1183  
00:53:23,480 --> 00:53:21,090  
the question and the ongoing story of

1184  
00:53:24,740 --> 00:53:23,490  
water on the moon thank you Mike and

1185  
00:53:28,760 --> 00:53:24,750  
thank you palace we're going to wrap it

1186  
00:53:31,580 --> 00:53:28,770  
up you can of course go to ww NSA govt

1187  
00:53:33,560 --> 00:53:31,590  
fall exciting new findings not just here

1188  
00:53:37,280 --> 00:53:33,570

for the moon but an upcoming Mars

1189

00:53:39,140 --> 00:53:37,290

briefing that briefing teleconference

1190

00:53:42,200 --> 00:53:39,150

will also be streamed on the news audio

1191

00:53:46,280 --> 00:53:42,210

my congratulations to the folks here on

1192

00:53:49,910 --> 00:53:46,290

the west coast clearly NASA is an agency

1193

00:53:52,010 --> 00:53:49,920

for the people by the people and it's