
MESSENGER
NASA
#askNASA
Ask Questions on Twitter

1
00:00:03,909 --> 00:00:01,990
good afternoon

2
00:00:06,470 --> 00:00:03,919
my name is dwayne brown with nasa's

3
00:00:08,070 --> 00:00:06,480
office of communications and welcome to

4
00:00:10,310 --> 00:00:08,080
nasa headquarters

5
00:00:12,789 --> 00:00:10,320
today you will hear the latest findings

6
00:00:14,950 --> 00:00:12,799
from nasa's messenger spacecraft that

7
00:00:16,710 --> 00:00:14,960
has been studying the planet mercury in

8
00:00:19,349 --> 00:00:16,720
unprecedented detail

9
00:00:20,310 --> 00:00:19,359
since the spacecraft's historic arrival

10
00:00:22,310 --> 00:00:20,320
in march

11
00:00:25,029 --> 00:00:22,320
2011.

12
00:00:26,550 --> 00:00:25,039
we'll have brief presentations then open

13
00:00:29,269 --> 00:00:26,560

it up for questions starting here in

14
00:00:33,350 --> 00:00:29,279
washington on nasa centers the phone

15
00:00:36,950 --> 00:00:33,360
lines and social media and visit nasa

16
00:00:39,590 --> 00:00:36,960
sodium media venues facebook

17
00:00:40,869 --> 00:00:39,600
youtube and twitter yes join the

18
00:00:42,549 --> 00:00:40,879
conversation

19
00:00:44,790 --> 00:00:42,559
with the hashtag

20
00:00:46,470 --> 00:00:44,800
ask nasa

21
00:00:49,190 --> 00:00:46,480
you can also follow

22
00:00:54,790 --> 00:00:49,200
the mission activities and updates

23
00:00:58,389 --> 00:00:56,869
messenger

24
00:01:00,069 --> 00:00:58,399
before we get into the briefings i'd

25
00:01:01,430 --> 00:01:00,079
like to introduce you to today's

26
00:01:03,110 --> 00:01:01,440
participants

27
00:01:05,270 --> 00:01:03,120
first up

28
00:01:08,230 --> 00:01:05,280
sean solomon

29
00:01:11,109 --> 00:01:08,240
messenger principal investigator

30
00:01:16,630 --> 00:01:11,119
lamont dougherty earth observatory

31
00:01:21,190 --> 00:01:18,550
david lawrence

32
00:01:24,230 --> 00:01:21,200
messenger participating scientist the

33
00:01:25,429 --> 00:01:24,240
johns hopkins university applied physics

34
00:01:31,030 --> 00:01:25,439
laboratory

35
00:01:34,950 --> 00:01:32,550
gregory newman

36
00:01:37,190 --> 00:01:34,960
mercury laser altimeter

37
00:01:44,469 --> 00:01:37,200
instrument scientist from nasa's goddard

38
00:01:47,670 --> 00:01:46,469

and david page

39
00:01:49,510 --> 00:01:47,680
messenger

40
00:01:50,870 --> 00:01:49,520
participating scientists

41
00:01:53,270 --> 00:01:50,880
from ucla

42
00:01:54,469 --> 00:01:53,280
now before we hear from

43
00:01:55,749 --> 00:01:54,479
our briefers

44
00:01:57,590 --> 00:01:55,759
i'd like to

45
00:01:59,429 --> 00:01:57,600
invite to the podium

46
00:02:01,510 --> 00:01:59,439
dr jim green

47
00:02:03,670 --> 00:02:01,520
the head of nasa's planetary science

48
00:02:12,150 --> 00:02:03,680
division to set the stage for us today

49
00:02:16,150 --> 00:02:14,150
well thank you very much duane and this

50
00:02:17,190 --> 00:02:16,160
indeed is going to be an exciting press

51
00:02:19,670 --> 00:02:17,200
conference

52
00:02:21,589 --> 00:02:19,680
you know the nasa planetary program has

53
00:02:23,589 --> 00:02:21,599
an array of missions that are scattered

54
00:02:26,550 --> 00:02:23,599
throughout the solar system and these

55
00:02:29,190 --> 00:02:26,560
are making really exciting measurements

56
00:02:30,630 --> 00:02:29,200
leading to fabulous discoveries those

57
00:02:32,390 --> 00:02:30,640
discoveries

58
00:02:34,150 --> 00:02:32,400
increase our knowledge but more

59
00:02:36,309 --> 00:02:34,160
importantly

60
00:02:39,110 --> 00:02:36,319
provide us a better understanding of the

61
00:02:41,110 --> 00:02:39,120
origin and evolution of our solar system

62
00:02:42,309 --> 00:02:41,120
for which the earth of course is a

63
00:02:44,150 --> 00:02:42,319

member of

64
00:02:46,390 --> 00:02:44,160
today we are here to talk about the

65
00:02:47,270 --> 00:02:46,400
results from the messenger mercury

66
00:02:49,589 --> 00:02:47,280
mission

67
00:02:50,949 --> 00:02:49,599
now messenger is one of nasa's discovery

68
00:02:53,270 --> 00:02:50,959
missions

69
00:02:57,990 --> 00:02:53,280
it's designed to do the first

70
00:03:00,309 --> 00:02:58,000
comprehensive global survey of mercury

71
00:03:04,149 --> 00:03:00,319
nasa's discovery program which began in

72
00:03:05,670 --> 00:03:04,159
1992 has initiated and flown 11 missions

73
00:03:07,910 --> 00:03:05,680
and in fact we're working on the 12th

74
00:03:09,990 --> 00:03:07,920
one now

75
00:03:12,149 --> 00:03:10,000
messenger has been inserted as dwayne

76
00:03:14,229 --> 00:03:12,159
messen mentioned into orbit about two

77
00:03:16,949 --> 00:03:14,239
years ago and has worked absolutely

78
00:03:19,430 --> 00:03:16,959
flawlessly during that time period

79
00:03:22,790 --> 00:03:19,440
and so without further ado let me turn

80
00:03:25,190 --> 00:03:22,800
it over to dr sean solomon the principal

81
00:03:28,630 --> 00:03:25,200
investigator for the messenger mercury

82
00:03:31,030 --> 00:03:28,640
mission sean thank you jim

83
00:03:33,350 --> 00:03:31,040
it has long been postulated

84
00:03:34,550 --> 00:03:33,360
that on mercury the planet closest to

85
00:03:36,229 --> 00:03:34,560
the sun

86
00:03:38,229 --> 00:03:36,239
there are cold

87
00:03:40,789 --> 00:03:38,239
permanently shadowed regions

88
00:03:43,509 --> 00:03:40,799

at the north and south poles

89
00:03:44,550 --> 00:03:43,519
where water and other volatiles may be

90
00:03:47,110 --> 00:03:44,560
stable

91
00:03:50,470 --> 00:03:47,120
as ices over time scales as long as

92
00:03:52,550 --> 00:03:50,480
millions or billions of years

93
00:03:54,070 --> 00:03:52,560
20 years ago

94
00:03:57,509 --> 00:03:54,080
radar astronomers announced the

95
00:03:59,990 --> 00:03:57,519
discovery that mercury has radar bright

96
00:04:02,630 --> 00:04:00,000
materials at its pulse as you see in the

97
00:04:04,630 --> 00:04:02,640
first image shown on the screen of the

98
00:04:06,149 --> 00:04:04,640
north polar region of mercury those

99
00:04:08,390 --> 00:04:06,159
radar bright materials are shown in

100
00:04:10,949 --> 00:04:08,400
yellow on that image

101
00:04:13,270 --> 00:04:10,959
and those materials have the radar

102
00:04:15,830 --> 00:04:13,280
characteristics that are best matched

103
00:04:18,629 --> 00:04:15,840
elsewhere in the solar system by water

104
00:04:20,789 --> 00:04:18,639
ice leading to the postulate 20 years

105
00:04:22,629 --> 00:04:20,799
ago that these radar

106
00:04:24,310 --> 00:04:22,639
bright deposits indeed consist

107
00:04:26,469 --> 00:04:24,320
dominantly of

108
00:04:27,909 --> 00:04:26,479
of water ice

109
00:04:29,590 --> 00:04:27,919
and in fact when

110
00:04:31,670 --> 00:04:29,600
where those images obtained by radar

111
00:04:34,710 --> 00:04:31,680
overlapped the images that the mariner

112
00:04:38,629 --> 00:04:34,720
10 spacecraft obtained of mercury uh

113
00:04:40,310 --> 00:04:38,639

with its cameras in 1974 and 1975 when

114
00:04:42,629 --> 00:04:40,320
it flew by the innermost planet three

115
00:04:46,790 --> 00:04:42,639
times the radar bright deposits were

116
00:04:49,749 --> 00:04:46,800
seen to lie within impact craters

117
00:04:53,030 --> 00:04:49,759
nonetheless in 20 years since that

118
00:04:54,870 --> 00:04:53,040
discovery other proposals have been made

119
00:04:56,950 --> 00:04:54,880
that the radar bright deposits might

120
00:04:58,310 --> 00:04:56,960
consist of some other materials than

121
00:05:00,230 --> 00:04:58,320
water ice

122
00:05:02,790 --> 00:05:00,240
and there have been no direct

123
00:05:04,710 --> 00:05:02,800
measurements of the composition or the

124
00:05:06,710 --> 00:05:04,720
detailed physical characteristics of

125
00:05:08,710 --> 00:05:06,720
those deposits until the messenger

126
00:05:11,110 --> 00:05:08,720
mission

127
00:05:13,270 --> 00:05:11,120
since insertion into orbit around

128
00:05:15,189 --> 00:05:13,280
mercury in march of last year

129
00:05:17,670 --> 00:05:15,199
messengers has undertaken a

130
00:05:18,870 --> 00:05:17,680
comprehensive campaign of the polar

131
00:05:20,790 --> 00:05:18,880
regions

132
00:05:23,110 --> 00:05:20,800
and the next slide shows

133
00:05:24,550 --> 00:05:23,120
a mosaic of images taken from the north

134
00:05:25,749 --> 00:05:24,560
polar region

135
00:05:28,310 --> 00:05:25,759
confirming

136
00:05:31,110 --> 00:05:28,320
what mariner 10 showed us

137
00:05:33,990 --> 00:05:31,120
after the radar deposits were discovered

138
00:05:36,469 --> 00:05:34,000

then indeed throughout the polar regions

139
00:05:37,590 --> 00:05:36,479
the largest of the radar right deposits

140
00:05:40,790 --> 00:05:37,600
do

141
00:05:42,870 --> 00:05:40,800
lie within impact craters

142
00:05:45,510 --> 00:05:42,880
and you can see from this image of the

143
00:05:48,629 --> 00:05:45,520
north pole that the deposits farthest

144
00:05:52,150 --> 00:05:48,639
from the pole are concentrated on the

145
00:05:54,390 --> 00:05:52,160
pole word facing walls and floor of the

146
00:05:56,550 --> 00:05:54,400
impact craters

147
00:06:01,270 --> 00:05:56,560
the imaging that messenger carried out

148
00:06:02,710 --> 00:06:01,280
also allowed us to delineate those areas

149
00:06:04,950 --> 00:06:02,720
that received no

150
00:06:06,469 --> 00:06:04,960
illumination from the sun at all over

151
00:06:09,189 --> 00:06:06,479
the course of an entire

152
00:06:12,550 --> 00:06:09,199
mercury solar day and the next image

153
00:06:15,350 --> 00:06:12,560
compares in red the areas that are in

154
00:06:17,670 --> 00:06:15,360
persistent shadow with the locations of

155
00:06:19,590 --> 00:06:17,680
the radar bright deposits imaged

156
00:06:21,189 --> 00:06:19,600
in the best resolution images obtained

157
00:06:23,749 --> 00:06:21,199
at the arecibo

158
00:06:24,469 --> 00:06:23,759
red radio observatory in puerto rico

159
00:06:26,230 --> 00:06:24,479
and

160
00:06:28,390 --> 00:06:26,240
you can see this result which is is

161
00:06:30,870 --> 00:06:28,400
duplicated in the south polar region

162
00:06:32,230 --> 00:06:30,880
that all of the radar bright deposits

163
00:06:34,070 --> 00:06:32,240

are in areas

164
00:06:36,309 --> 00:06:34,080
that are persistently shadowed over the

165
00:06:38,309 --> 00:06:36,319
course of a mercury solar day

166
00:06:40,550 --> 00:06:38,319
this is indeed

167
00:06:43,110 --> 00:06:40,560
consistent with the proposal that the

168
00:06:43,990 --> 00:06:43,120
radar bright deposits are some kind of

169
00:06:45,909 --> 00:06:44,000
ice

170
00:06:48,469 --> 00:06:45,919
cold trapped in permanently shadowed

171
00:06:49,830 --> 00:06:48,479
regions

172
00:06:51,430 --> 00:06:49,840
today

173
00:06:53,189 --> 00:06:51,440
there are three papers that have been

174
00:06:54,950 --> 00:06:53,199
published online

175
00:06:57,990 --> 00:06:54,960
by science magazine

176
00:07:01,110 --> 00:06:58,000
led by my three colleagues to my left

177
00:07:03,029 --> 00:07:01,120
each one of them that present three new

178
00:07:05,670 --> 00:07:03,039
lines of evidence

179
00:07:07,830 --> 00:07:05,680
that it is water ice indeed

180
00:07:09,990 --> 00:07:07,840
that dominates the composition of the

181
00:07:12,070 --> 00:07:10,000
polar deposits on mercury

182
00:07:15,029 --> 00:07:12,080
one of those papers deals with

183
00:07:16,629 --> 00:07:15,039
measurements of the flux of neutrons

184
00:07:18,790 --> 00:07:16,639
in the polar regions

185
00:07:21,110 --> 00:07:18,800
one of those papers deals with the

186
00:07:22,550 --> 00:07:21,120
active measurement of the reflectance of

187
00:07:25,270 --> 00:07:22,560
mercury's surface

188
00:07:27,350 --> 00:07:25,280

and one of those papers deals with new

189
00:07:29,749 --> 00:07:27,360
models for the temperature of the

190
00:07:32,150 --> 00:07:29,759
surface and near-service region

191
00:07:35,110 --> 00:07:32,160
regions near the north pole

192
00:07:36,550 --> 00:07:35,120
determined on the basis of measured

193
00:07:37,670 --> 00:07:36,560
topography

194
00:07:38,950 --> 00:07:37,680
that

195
00:07:40,950 --> 00:07:38,960
has been obtained by the messenger

196
00:07:42,550 --> 00:07:40,960
spacecraft

197
00:07:44,790 --> 00:07:42,560
the next slide

198
00:07:46,390 --> 00:07:44,800
shows that obtaining these measurements

199
00:07:47,270 --> 00:07:46,400
has not been easy and it has not been

200
00:07:51,029 --> 00:07:47,280
quick

201
00:07:54,230 --> 00:07:51,039
the messenger spacecraft for 13 months

202
00:07:56,309 --> 00:07:54,240
was in a 12-hour orbit the orbit is not

203
00:07:57,430 --> 00:07:56,319
strictly polar and it is highly

204
00:07:59,510 --> 00:07:57,440
eccentric

205
00:08:02,309 --> 00:07:59,520
and even at the highest latitudes

206
00:08:05,830 --> 00:08:02,319
reached by the messenger spacecraft

207
00:08:08,469 --> 00:08:05,840
the vantage point is anywhere from 250

208
00:08:11,510 --> 00:08:08,479
to 600 kilometers off the surface

209
00:08:13,510 --> 00:08:11,520
and moreover the spacecraft must look uh

210
00:08:15,350 --> 00:08:13,520
and an oblique angle to see the very

211
00:08:17,510 --> 00:08:15,360
highest latitudes

212
00:08:19,909 --> 00:08:17,520
since april of this year messenger has

213
00:08:22,869 --> 00:08:19,919

been in an eight hour orbit but

214
00:08:26,469 --> 00:08:22,879
it's still at very high altitudes 250 to

215
00:08:29,350 --> 00:08:26,479
400 kilometers off the surface at its

216
00:08:31,749 --> 00:08:29,360
highest northern extent

217
00:08:32,630 --> 00:08:31,759
despite the challenges to obtaining

218
00:08:37,190 --> 00:08:32,640
these

219
00:08:39,269 --> 00:08:37,200
methods as you will see momentarily the

220
00:08:41,909 --> 00:08:39,279
one and a half years of observations

221
00:08:43,269 --> 00:08:41,919
that messenger has completed have now

222
00:08:45,990 --> 00:08:43,279
finally

223
00:08:48,230 --> 00:08:46,000
yielded very clear results and for the

224
00:08:50,870 --> 00:08:48,240
first of those results let me turn to my

225
00:08:53,910 --> 00:08:50,880
colleague on my left david lawrence

226
00:08:56,949 --> 00:08:53,920
okay thank you sean and so for this part

227
00:08:59,829 --> 00:08:56,959
of the story of this 20-year story that

228
00:09:01,910 --> 00:08:59,839
we have of ice at the poles of mercury i

229
00:09:04,150 --> 00:09:01,920
will be presenting results of hydrogen

230
00:09:06,550 --> 00:09:04,160
concentrations at the north pole of

231
00:09:08,470 --> 00:09:06,560
mercury and by measuring hydrogen we can

232
00:09:11,509 --> 00:09:08,480
infer information about the water ice

233
00:09:13,430 --> 00:09:11,519
concentration at the poles mercury

234
00:09:16,070 --> 00:09:13,440
and we use a technique that's called

235
00:09:17,910 --> 00:09:16,080
planetary neutron spectroscopy and this

236
00:09:20,310 --> 00:09:17,920
is a technique that's been successfully

237
00:09:23,110 --> 00:09:20,320
used to measure hydrogen at the moon

238
00:09:25,269 --> 00:09:23,120

at mars and most recently at the

239
00:09:26,310 --> 00:09:25,279
asteroid vesta as part of the dawn

240
00:09:28,630 --> 00:09:26,320
mission

241
00:09:30,710 --> 00:09:28,640
and what we do is we measure neutrons

242
00:09:32,870 --> 00:09:30,720
that are liberated off the surface of

243
00:09:34,870 --> 00:09:32,880
the planet uh by particles that are

244
00:09:37,590 --> 00:09:34,880
called galactic cosmic rays and if i can

245
00:09:39,990 --> 00:09:37,600
have the the first graphic please

246
00:09:41,829 --> 00:09:40,000
and cosmic rays they're just very

247
00:09:43,590 --> 00:09:41,839
fast-moving protons that are flying

248
00:09:44,870 --> 00:09:43,600
throughout the solar system and the

249
00:09:46,949 --> 00:09:44,880
galaxy

250
00:09:49,190 --> 00:09:46,959
and when they hit the surface of a

251
00:09:51,269 --> 00:09:49,200
planet like mercury they bust apart the

252
00:09:53,829 --> 00:09:51,279
atomic nuclei and these nuclei contain

253
00:09:55,269 --> 00:09:53,839
neutrons can i have the next graphic

254
00:09:56,710 --> 00:09:55,279
and so these neutrons which are

255
00:09:57,590 --> 00:09:56,720
illustrated as the

256
00:09:59,590 --> 00:09:57,600
narrow

257
00:10:01,509 --> 00:09:59,600
yellow lines they rattle around the

258
00:10:02,550 --> 00:10:01,519
surface and some of them escape into

259
00:10:04,949 --> 00:10:02,560
space

260
00:10:06,550 --> 00:10:04,959
at which time they can be detected by an

261
00:10:08,870 --> 00:10:06,560
instrument called a neutron spectrometer

262
00:10:10,230 --> 00:10:08,880
that's flying on board the messenger

263
00:10:12,389 --> 00:10:10,240

spacecraft

264
00:10:14,389 --> 00:10:12,399
now if you happen to have a situation

265
00:10:15,990 --> 00:10:14,399
where a crater say at the north pole is

266
00:10:17,269 --> 00:10:16,000
illustrating this graph it contains

267
00:10:19,350 --> 00:10:17,279
water ice

268
00:10:21,910 --> 00:10:19,360
can i have the next graphic

269
00:10:24,630 --> 00:10:21,920
it turns out that of course water ice is

270
00:10:27,030 --> 00:10:24,640
h2o so it contains lots of hydrogen well

271
00:10:29,110 --> 00:10:27,040
the hydrogen in the water ice stops the

272
00:10:31,030 --> 00:10:29,120
neutrons very quickly

273
00:10:32,710 --> 00:10:31,040
and so the telltale signature almost in

274
00:10:35,110 --> 00:10:32,720
a unique way that you would have

275
00:10:37,430 --> 00:10:35,120
enhanced hydrogen is a decrease

276
00:10:38,870 --> 00:10:37,440
in the number of measured neutrons

277
00:10:39,990 --> 00:10:38,880
that you would see as you're flying over

278
00:10:41,509 --> 00:10:40,000
the crater and so that's what we're

279
00:10:42,790 --> 00:10:41,519
looking for is a decrease in the number

280
00:10:45,509 --> 00:10:42,800
of measured neutrons to tell us that

281
00:10:46,870 --> 00:10:45,519
there's enhanced hydrogen

282
00:10:48,550 --> 00:10:46,880
now in the next set of graphics i'll

283
00:10:50,150 --> 00:10:48,560
give a few words about how it is that we

284
00:10:52,710 --> 00:10:50,160
make this measurement on the messenger

285
00:10:55,430 --> 00:10:52,720
spacecraft can i have the next graphic

286
00:10:58,069 --> 00:10:55,440
this is a perspective view of mercury's

287
00:11:01,829 --> 00:10:58,079
north pole where we have these

288
00:11:03,990 --> 00:11:01,839

radar bright deposits discussed by sean

289
00:11:06,550 --> 00:11:04,000
and we can simulate what these would

290
00:11:08,949 --> 00:11:06,560
look like if you say put on neutron

291
00:11:10,069 --> 00:11:08,959
glasses as it were can i have the next

292
00:11:12,470 --> 00:11:10,079
slide

293
00:11:14,389 --> 00:11:12,480
and if your neutron glasses had perfect

294
00:11:15,110 --> 00:11:14,399
focus this is the view that you would

295
00:11:16,150 --> 00:11:15,120
see

296
00:11:17,750 --> 00:11:16,160
and again

297
00:11:19,910 --> 00:11:17,760
where you have areas of enhanced

298
00:11:22,470 --> 00:11:19,920
hydrogen you would see a decrease in the

299
00:11:24,470 --> 00:11:22,480
number of neutrons now it turns out that

300
00:11:26,230 --> 00:11:24,480
planetary neutron spectrometers do not

301
00:11:27,350 --> 00:11:26,240
have perfect focus they're in fact quite

302
00:11:29,030 --> 00:11:27,360
blurry

303
00:11:31,350 --> 00:11:29,040
can i have the next slide

304
00:11:33,590 --> 00:11:31,360
this is what we would actually see

305
00:11:35,829 --> 00:11:33,600
when we're measuring over going over the

306
00:11:38,069 --> 00:11:35,839
mercury's north pole we can't resolve

307
00:11:39,430 --> 00:11:38,079
individual craters spatially

308
00:11:41,430 --> 00:11:39,440
nonetheless

309
00:11:43,670 --> 00:11:41,440
the telltale signature of hydrogen is

310
00:11:45,190 --> 00:11:43,680
still there if it if

311
00:11:47,110 --> 00:11:45,200
if you have the enhanced hydrogen and

312
00:11:48,630 --> 00:11:47,120
again that's a decrease in the number of

313
00:11:51,829 --> 00:11:48,640

neutrons that you would see as you're

314
00:11:55,430 --> 00:11:51,839
flying over mercury's north pole

315
00:11:58,069 --> 00:11:55,440
now what we can do is compare messenger

316
00:12:00,870 --> 00:11:58,079
neutron data with two hypotheses and the

317
00:12:03,030 --> 00:12:00,880
two hypotheses are the following one

318
00:12:05,750 --> 00:12:03,040
that these radar bright regions contain

319
00:12:08,550 --> 00:12:05,760
very little to no water ice the second

320
00:12:10,550 --> 00:12:08,560
hypothesis is that they are filled with

321
00:12:11,509 --> 00:12:10,560
water ice can i have the next graphic

322
00:12:13,509 --> 00:12:11,519
please

323
00:12:15,030 --> 00:12:13,519
and so what this shows is a plot of

324
00:12:16,949 --> 00:12:15,040
simulated

325
00:12:19,269 --> 00:12:16,959
neutron behavior

326
00:12:21,430 --> 00:12:19,279
where on the vertical axis we have a

327
00:12:23,590 --> 00:12:21,440
quantity called relative flux this is

328
00:12:24,949 --> 00:12:23,600
just a fancy name for number of neutrons

329
00:12:27,269 --> 00:12:24,959
that you detect

330
00:12:28,790 --> 00:12:27,279
for different latitudes that you would

331
00:12:30,310 --> 00:12:28,800
make the measurement at and the latitude

332
00:12:32,550 --> 00:12:30,320
is shown on the horizontal axis and the

333
00:12:34,550 --> 00:12:32,560
north pole is towards the right

334
00:12:36,550 --> 00:12:34,560
now the little to no water ice

335
00:12:38,230 --> 00:12:36,560
hypothesis is shown in the white line

336
00:12:39,829 --> 00:12:38,240
and what you see is that the neutrons

337
00:12:41,829 --> 00:12:39,839
would show very little variation as you

338
00:12:44,790 --> 00:12:41,839

go towards from the equator towards the

339
00:12:46,790 --> 00:12:44,800
north pole in contrast the

340
00:12:49,110 --> 00:12:46,800
lots of ice hypothesis

341
00:12:51,350 --> 00:12:49,120
filling up these regions with pure ice

342
00:12:54,230 --> 00:12:51,360
would be shown in the blue line and

343
00:12:55,590 --> 00:12:54,240
again as you approach these radar bright

344
00:12:57,590 --> 00:12:55,600
regions if they contain enhanced

345
00:12:59,030 --> 00:12:57,600
hydrogen you would see decreases in the

346
00:13:01,110 --> 00:12:59,040
number of neutrons

347
00:13:02,310 --> 00:13:01,120
next slide please

348
00:13:04,870 --> 00:13:02,320
and so now what we've done is

349
00:13:07,670 --> 00:13:04,880
superimposed messenger neutron data on

350
00:13:11,350 --> 00:13:07,680
top of those two simulations and what we

351
00:13:13,990 --> 00:13:11,360
see very clearly is that the data

352
00:13:16,710 --> 00:13:14,000
track extraordinarily nicely with the

353
00:13:19,350 --> 00:13:16,720
simulation that says we have

354
00:13:21,350 --> 00:13:19,360
enhanced hydrogen and so from these data

355
00:13:22,710 --> 00:13:21,360
we can conclude number one there is

356
00:13:26,069 --> 00:13:22,720
certainly an enhanced hydrogen

357
00:13:27,269 --> 00:13:26,079
abundances at mercury's north pole

358
00:13:30,230 --> 00:13:27,279
secondly

359
00:13:31,990 --> 00:13:30,240
it's quantitatively agrees with the

360
00:13:34,230 --> 00:13:32,000
amount of hydrogen you get if these

361
00:13:35,509 --> 00:13:34,240
radar bright regions are filled with

362
00:13:37,190 --> 00:13:35,519
water ice

363
00:13:39,590 --> 00:13:37,200

finally when we combine this neutron

364
00:13:41,509 --> 00:13:39,600
information with other information such

365
00:13:43,910 --> 00:13:41,519
as the radar data

366
00:13:46,949 --> 00:13:43,920
the areas of permanent shade

367
00:13:49,509 --> 00:13:46,959
we have very compelling evidence that

368
00:13:50,710 --> 00:13:49,519
these regions are indeed filled with

369
00:13:51,590 --> 00:13:50,720
water ice

370
00:13:54,150 --> 00:13:51,600
now

371
00:13:55,269 --> 00:13:54,160
in summary we can ask the questions how

372
00:14:00,069 --> 00:13:55,279
much

373
00:14:01,590 --> 00:14:00,079
and for this we can combine both north

374
00:14:03,189 --> 00:14:01,600
and south poles because this the

375
00:14:05,030 --> 00:14:03,199
situation in the south is very similar

376
00:14:06,949 --> 00:14:05,040
to the north well it turns out if you

377
00:14:09,990 --> 00:14:06,959
add it all up you have on the order of a

378
00:14:12,629 --> 00:14:10,000
hundred billion to one trillion metric

379
00:14:14,870 --> 00:14:12,639
tons of ice and the uncertainty on that

380
00:14:16,629 --> 00:14:14,880
number is just how deep it goes

381
00:14:19,430 --> 00:14:16,639
we think it's at least 50 centimeters

382
00:14:20,949 --> 00:14:19,440
deep it could be as deep as 20 meters

383
00:14:22,470 --> 00:14:20,959
now of course those numbers are big it's

384
00:14:23,990 --> 00:14:22,480
hard to know what to do with them so we

385
00:14:27,030 --> 00:14:24,000
can bring it down to earth and in fact

386
00:14:29,910 --> 00:14:27,040
here in this town if you take the amount

387
00:14:31,269 --> 00:14:29,920
of ice that we consider to be at mercury

388
00:14:33,189 --> 00:14:31,279

right now

389
00:14:35,269 --> 00:14:33,199
stack up the entire area of washington

390
00:14:36,230 --> 00:14:35,279
dc by about two to two and a half miles

391
00:14:38,310 --> 00:14:36,240
of ice

392
00:14:41,030 --> 00:14:38,320
that's what's present currently

393
00:14:43,350 --> 00:14:41,040
at mercury's poles according to our data

394
00:14:45,350 --> 00:14:43,360
so these are very exciting results that

395
00:14:47,590 --> 00:14:45,360
we can sort of bring these all together

396
00:14:49,509 --> 00:14:47,600
but there's more to come and the next

397
00:14:51,670 --> 00:14:49,519
set of results are going to be given by

398
00:14:53,910 --> 00:14:51,680
greg newman with data from the mercury

399
00:14:55,990 --> 00:14:53,920
laser altimeter thank you thank you

400
00:14:57,829 --> 00:14:56,000
david if you take off your neutron

401
00:15:00,230 --> 00:14:57,839
glasses now and put on your infrared

402
00:15:03,189 --> 00:15:00,240
glasses i will talk about the instrument

403
00:15:05,670 --> 00:15:03,199
the mercury laser altimeter or mla

404
00:15:07,829 --> 00:15:05,680
also on messenger

405
00:15:10,389 --> 00:15:07,839
this instrument has been

406
00:15:12,710 --> 00:15:10,399
mapping the surface of

407
00:15:15,189 --> 00:15:12,720
mercury and produce topographic maps

408
00:15:17,590 --> 00:15:15,199
i'll show a movie please

409
00:15:19,350 --> 00:15:17,600
that illustrates how a laser altimeter

410
00:15:21,990 --> 00:15:19,360
operates

411
00:15:25,350 --> 00:15:22,000
it shows a generic spacecraft orbiting a

412
00:15:26,870 --> 00:15:25,360
planet like mercury or mars or the moon

413
00:15:28,069 --> 00:15:26,880

and we've done this in

414
00:15:29,590 --> 00:15:28,079
in

415
00:15:32,629 --> 00:15:29,600
those places

416
00:15:33,749 --> 00:15:32,639
it fires a spear-like laser pulse to the

417
00:15:36,150 --> 00:15:33,759
surface

418
00:15:37,990 --> 00:15:36,160
using the energy of a flashlight

419
00:15:40,389 --> 00:15:38,000
and it can

420
00:15:42,230 --> 00:15:40,399
record the distance to the surface

421
00:15:44,629 --> 00:15:42,240
by measuring the time that it takes for

422
00:15:46,230 --> 00:15:44,639
this pulse to bounce off the surface and

423
00:15:47,910 --> 00:15:46,240
then come back usually less than a

424
00:15:50,150 --> 00:15:47,920
hundredth of a second

425
00:15:51,829 --> 00:15:50,160
this measurement of time is so accurate

426
00:15:54,629 --> 00:15:51,839
that we can measure the distance to the

427
00:15:57,269 --> 00:15:54,639
thickness of one's hand or the width of

428
00:16:00,230 --> 00:15:57,279
one's hand and doing this eight times a

429
00:16:02,629 --> 00:16:00,240
second we build up a topographic map

430
00:16:05,430 --> 00:16:02,639
of the whole northern hemisphere the the

431
00:16:08,230 --> 00:16:05,440
next graphic please will show that it

432
00:16:12,069 --> 00:16:08,240
also measures the reflectance

433
00:16:13,910 --> 00:16:12,079
as a function of the outgoing versus the

434
00:16:16,550 --> 00:16:13,920
received energy

435
00:16:18,550 --> 00:16:16,560
on the left you see the laser pulse just

436
00:16:21,189 --> 00:16:18,560
a few nanoseconds wide or billionths of

437
00:16:23,990 --> 00:16:21,199
a second wide being fired at the surface

438
00:16:27,269 --> 00:16:24,000

of mercury from messenger spacecraft and

439
00:16:30,150 --> 00:16:27,279
it hits a spot about the size of a house

440
00:16:31,590 --> 00:16:30,160
and then returns to the

441
00:16:33,990 --> 00:16:31,600
receiver telescope you see the

442
00:16:36,790 --> 00:16:34,000
instrument on the right

443
00:16:38,949 --> 00:16:36,800
and a few dozen photons are collected

444
00:16:41,350 --> 00:16:38,959
rather than count the individual photons

445
00:16:44,389 --> 00:16:41,360
we transform them electronically into a

446
00:16:46,470 --> 00:16:44,399
waveform and this waveform is measured

447
00:16:48,790 --> 00:16:46,480
at two different voltage thresholds

448
00:16:50,389 --> 00:16:48,800
which gives us uh with the times four

449
00:16:53,430 --> 00:16:50,399
different points that we can use to

450
00:16:56,470 --> 00:16:53,440
estimate the area under the waveform as

451
00:16:58,870 --> 00:16:56,480
a triangle and then we take the ratio of

452
00:17:01,189 --> 00:16:58,880
the received energy over the transmitted

453
00:17:03,509 --> 00:17:01,199
energy that gives us the reflectance

454
00:17:05,750 --> 00:17:03,519
uh the reflectivity of the

455
00:17:07,990 --> 00:17:05,760
polar regions can be done in complete

456
00:17:10,870 --> 00:17:08,000
darkness as well as in light because

457
00:17:12,150 --> 00:17:10,880
it's an active instrument

458
00:17:15,110 --> 00:17:12,160
so

459
00:17:18,390 --> 00:17:15,120
the next slide will show the topography

460
00:17:19,669 --> 00:17:18,400
of the north polar region which we've

461
00:17:21,829 --> 00:17:19,679
now covered

462
00:17:24,549 --> 00:17:21,839
the surface of mercury down to the

463
00:17:26,870 --> 00:17:24,559

equator with the laser altimeter but in

464
00:17:29,990 --> 00:17:26,880
the north pole region we have very dense

465
00:17:31,750 --> 00:17:30,000
coverage up to the inclination of

466
00:17:35,029 --> 00:17:31,760
messenger's orbit and then with

467
00:17:36,870 --> 00:17:35,039
off-nader observations we can move uh

468
00:17:40,230 --> 00:17:36,880
even further towards the north pole

469
00:17:43,110 --> 00:17:40,240
shown by the arrows on the left

470
00:17:44,549 --> 00:17:43,120
these observations are less clear and

471
00:17:45,990 --> 00:17:44,559
some of them are

472
00:17:48,549 --> 00:17:46,000
there are gaps where we haven't been

473
00:17:51,110 --> 00:17:48,559
able to obtain coverage yet but we will

474
00:17:54,549 --> 00:17:51,120
i want to draw your attention to the

475
00:17:57,029 --> 00:17:54,559
large crater uh colored in deep blue for

476
00:18:00,549 --> 00:17:57,039
for the deepest shades prokofiev in the

477
00:18:02,390 --> 00:18:00,559
center uh this crater uh is the deepest

478
00:18:03,510 --> 00:18:02,400
location that we've measured yet on

479
00:18:04,310 --> 00:18:03,520
mercury

480
00:18:05,110 --> 00:18:04,320
and

481
00:18:07,590 --> 00:18:05,120
is

482
00:18:10,630 --> 00:18:07,600
as you've seen in the previous slides

483
00:18:13,029 --> 00:18:10,640
it contains radar bright deposits

484
00:18:13,830 --> 00:18:13,039
the other craters as well that you see

485
00:18:15,190 --> 00:18:13,840
here

486
00:18:17,830 --> 00:18:15,200
largely are

487
00:18:20,150 --> 00:18:17,840
containers for radar bright deposits the

488
00:18:22,630 --> 00:18:20,160

shaded relief shows you what the the

489
00:18:25,590 --> 00:18:22,640
terrain looks like as if they were

490
00:18:28,549 --> 00:18:25,600
illuminated from the equator and it

491
00:18:31,029 --> 00:18:28,559
shows that one wall of prokofiev is in

492
00:18:32,470 --> 00:18:31,039
shadow and the other wall is

493
00:18:35,190 --> 00:18:32,480
in sunlight

494
00:18:37,590 --> 00:18:35,200
we can use the accurate topography

495
00:18:40,710 --> 00:18:37,600
to determine what the illumination of

496
00:18:41,590 --> 00:18:40,720
mercury is at any time of day

497
00:18:44,230 --> 00:18:41,600
and

498
00:18:47,350 --> 00:18:44,240
make quantitative measurements of the

499
00:18:49,029 --> 00:18:47,360
solar illumination the next

500
00:18:51,350 --> 00:18:49,039
movie will show

501
00:18:53,110 --> 00:18:51,360
starting with prokofiev in the center in

502
00:18:55,430 --> 00:18:53,120
complete darkness

503
00:18:57,350 --> 00:18:55,440
the surface of mercury we've

504
00:18:59,430 --> 00:18:57,360
stretched the contrast here because it

505
00:19:01,750 --> 00:18:59,440
is so dark there that you wouldn't be

506
00:19:03,990 --> 00:19:01,760
able to see it on the television

507
00:19:05,750 --> 00:19:04,000
then as the movie sweeps through

508
00:19:09,669 --> 00:19:05,760
the

509
00:19:12,070 --> 00:19:09,679
mercury solar day you will see

510
00:19:13,990 --> 00:19:12,080
the crater prokofiev could i have the

511
00:19:15,750 --> 00:19:14,000
movie please

512
00:19:18,630 --> 00:19:15,760
crater prokofiev in the center is

513
00:19:21,750 --> 00:19:18,640

briefly illuminated by the sun

514
00:19:23,110 --> 00:19:21,760
and the area the crescent shaped area

515
00:19:26,150 --> 00:19:23,120
just

516
00:19:29,110 --> 00:19:26,160
this the southern wall uh remains in

517
00:19:30,150 --> 00:19:29,120
shadow and as this repeats you will see

518
00:19:38,549 --> 00:19:30,160
the

519
00:19:41,990 --> 00:19:38,559
as it moves this is a completely

520
00:19:44,230 --> 00:19:42,000
synthetic rendering of course but is

521
00:19:46,549 --> 00:19:44,240
quantitatively accurate

522
00:19:48,310 --> 00:19:46,559
now with this illumination model we can

523
00:19:50,710 --> 00:19:48,320
calculate

524
00:19:52,870 --> 00:19:50,720
as the next speaker will describe the

525
00:19:55,830 --> 00:19:52,880
temperature as well as the elimination

526
00:20:00,630 --> 00:19:55,840
conditions in the interior

527
00:20:06,630 --> 00:20:03,430
that that area prokofiev which is about

528
00:20:09,110 --> 00:20:06,640
the size of the impact crater that

529
00:20:12,390 --> 00:20:09,120
formed the mouth of the chesapeake bay

530
00:20:15,110 --> 00:20:12,400
is one where we have the best of mla

531
00:20:17,990 --> 00:20:15,120
reflectance and as you see in the

532
00:20:19,750 --> 00:20:18,000
graphic that we'll show next the radar

533
00:20:22,149 --> 00:20:19,760
shows that this area is a

534
00:20:23,909 --> 00:20:22,159
crescent-shaped deposit of radar-bright

535
00:20:25,669 --> 00:20:23,919
material

536
00:20:27,830 --> 00:20:25,679
very large and

537
00:20:30,149 --> 00:20:27,840
we were able to obtain profiles across

538
00:20:31,510 --> 00:20:30,159

it after about a year of orbiting

539
00:20:34,549 --> 00:20:31,520
mercury

540
00:20:36,470 --> 00:20:34,559
this prokofiev crater deposit was our

541
00:20:39,510 --> 00:20:36,480
first real

542
00:20:42,630 --> 00:20:39,520
target of where we might see

543
00:20:44,390 --> 00:20:42,640
possible water ice and indeed

544
00:20:45,190 --> 00:20:44,400
as we go to the next graphic we will

545
00:20:47,669 --> 00:20:45,200
show

546
00:20:49,830 --> 00:20:47,679
that this area is

547
00:20:53,110 --> 00:20:49,840
very interesting from the point of view

548
00:20:56,149 --> 00:20:53,120
of reflectivity the map will show in

549
00:20:58,070 --> 00:20:56,159
gray the areas that we haven't covered

550
00:21:00,470 --> 00:20:58,080
the average background

551
00:21:03,430 --> 00:21:00,480
reflectance of mercury is shown as

552
00:21:05,909 --> 00:21:03,440
grayish white and

553
00:21:09,350 --> 00:21:05,919
the red is the areas where the

554
00:21:11,510 --> 00:21:09,360
reflectivity is two to four times higher

555
00:21:13,990 --> 00:21:11,520
than the average background of mercury

556
00:21:15,110 --> 00:21:14,000
now we we also show

557
00:21:17,510 --> 00:21:15,120
in dark

558
00:21:20,710 --> 00:21:17,520
the areas where the reflectance is at

559
00:21:22,230 --> 00:21:20,720
least twice as dark as the background of

560
00:21:24,549 --> 00:21:22,240
mercury

561
00:21:26,710 --> 00:21:24,559
so the two surprises were that yes we

562
00:21:28,549 --> 00:21:26,720
are seeing uh something that is as

563
00:21:31,510 --> 00:21:28,559

reflective as

564
00:21:34,630 --> 00:21:31,520
water ice as seen in

565
00:21:37,029 --> 00:21:34,640
other laser altimeters in the infrared

566
00:21:40,310 --> 00:21:37,039
and we're seeing it just exactly where

567
00:21:41,350 --> 00:21:40,320
the neutron spectrometers and the radar

568
00:21:44,549 --> 00:21:41,360
have

569
00:21:45,350 --> 00:21:44,559
also confirmed the existence of hydrogen

570
00:21:47,029 --> 00:21:45,360
and

571
00:21:49,909 --> 00:21:47,039
reflective material

572
00:21:52,789 --> 00:21:49,919
so the real surprise though was that

573
00:21:55,190 --> 00:21:52,799
there were dark areas inside

574
00:21:57,510 --> 00:21:55,200
and surrounding any of the bright areas

575
00:21:58,950 --> 00:21:57,520
that we have seen these dark areas were

576
00:22:01,750 --> 00:21:58,960
more pervasive

577
00:22:04,710 --> 00:22:01,760
than the radar bright areas

578
00:22:06,789 --> 00:22:04,720
and we have an interpretation for these

579
00:22:08,149 --> 00:22:06,799
areas that they are a blanket that

580
00:22:12,149 --> 00:22:08,159
protects

581
00:22:14,549 --> 00:22:12,159
whatever bright volatiles lie underneath

582
00:22:16,950 --> 00:22:14,559
so i will summarize these findings as

583
00:22:17,830 --> 00:22:16,960
saying the mercury laser altimeter can

584
00:22:20,549 --> 00:22:17,840
see

585
00:22:23,590 --> 00:22:20,559
something which is extremely bright and

586
00:22:26,630 --> 00:22:23,600
coincides with all the hypothesized

587
00:22:28,950 --> 00:22:26,640
ices that have been determined by other

588
00:22:31,430 --> 00:22:28,960

investigations so now i'll turn it over

589
00:22:33,510 --> 00:22:31,440
to my colleague david page who will

590
00:22:35,190 --> 00:22:33,520
describe the thermal models and how this

591
00:22:36,549 --> 00:22:35,200
all fits together

592
00:22:39,190 --> 00:22:36,559
thanks greg

593
00:22:41,190 --> 00:22:39,200
the distribution of ices on planetary

594
00:22:43,990 --> 00:22:41,200
bodies is a very strong function of

595
00:22:47,029 --> 00:22:44,000
temperature and in our science paper we

596
00:22:49,029 --> 00:22:47,039
did the first detailed thermal model of

597
00:22:51,669 --> 00:22:49,039
the near surface and surface of mercury

598
00:22:53,110 --> 00:22:51,679
based on the new messenger topography

599
00:22:55,190 --> 00:22:53,120
data

600
00:22:56,710 --> 00:22:55,200
the first graphic shows some results

601
00:22:58,549 --> 00:22:56,720
from that model from the viewpoint of

602
00:23:01,029 --> 00:22:58,559
the north polar region in a region where

603
00:23:01,830 --> 00:23:01,039
we've got the very best mla or mars

604
00:23:06,070 --> 00:23:01,840
laser

605
00:23:07,909 --> 00:23:06,080
topography data

606
00:23:10,789 --> 00:23:07,919
mercury as it turns out being the

607
00:23:12,710 --> 00:23:10,799
closest planet to the sun has the widest

608
00:23:15,190 --> 00:23:12,720
range of temperatures of any planetary

609
00:23:17,029 --> 00:23:15,200
body in the solar system at the equator

610
00:23:19,430 --> 00:23:17,039
temperatures can get up to

611
00:23:20,549 --> 00:23:19,440
700 degrees kelvin during the middle of

612
00:23:22,390 --> 00:23:20,559
the day

613
00:23:24,630 --> 00:23:22,400

and even at 80 degrees latitude where

614
00:23:27,590 --> 00:23:24,640
you're seeing right here uh annual

615
00:23:29,990 --> 00:23:27,600
maximum temperatures get up to about 550

616
00:23:32,149 --> 00:23:30,000
kelvin however when you get into the

617
00:23:33,750 --> 00:23:32,159
permanently shattered areas our models

618
00:23:36,470 --> 00:23:33,760
tell us that the temperatures can dip

619
00:23:38,630 --> 00:23:36,480
down to as low as 50 kelvin that's 50

620
00:23:41,430 --> 00:23:38,640
degrees celsius above absolute zero

621
00:23:43,190 --> 00:23:41,440
which is as cold as you can possibly get

622
00:23:46,789 --> 00:23:43,200
the thermal model also has the

623
00:23:48,789 --> 00:23:46,799
capability to tell us exactly where on

624
00:23:51,350 --> 00:23:48,799
the surface and below the surface

625
00:23:53,029 --> 00:23:51,360
different types of volatile materials

626
00:23:55,510 --> 00:23:53,039
ought to be stable

627
00:23:58,070 --> 00:23:55,520
and the next graphic shows our results

628
00:24:00,630 --> 00:23:58,080
showing the stability regions for water

629
00:24:03,190 --> 00:24:00,640
ice on the surface and subsurface of

630
00:24:04,630 --> 00:24:03,200
mercury the gray regions show areas that

631
00:24:07,110 --> 00:24:04,640
are too cold

632
00:24:08,470 --> 00:24:07,120
excuse me too warm to ever have ice

633
00:24:11,110 --> 00:24:08,480
being stable

634
00:24:13,350 --> 00:24:11,120
the colored areas show where below the

635
00:24:15,430 --> 00:24:13,360
surface of

636
00:24:17,909 --> 00:24:15,440
mercury would have temperatures that are

637
00:24:19,830 --> 00:24:17,919
conducive to water ice stability whereas

638
00:24:22,549 --> 00:24:19,840

on the surface in these colored areas

639
00:24:24,470 --> 00:24:22,559
it's too warm for water ice to be stable

640
00:24:27,350 --> 00:24:24,480
and then in this particular region there

641
00:24:29,510 --> 00:24:27,360
are a few areas where we color those

642
00:24:32,630 --> 00:24:29,520
white those are areas where water ice

643
00:24:35,029 --> 00:24:32,640
would be stable directly on the surface

644
00:24:37,110 --> 00:24:35,039
what we did in our paper was we compared

645
00:24:39,669 --> 00:24:37,120
the regions that we calculate to be

646
00:24:41,750 --> 00:24:39,679
water i stable with the areas that have

647
00:24:44,310 --> 00:24:41,760
been shown to be radar bright and we

648
00:24:46,470 --> 00:24:44,320
basically obtained a perfect match which

649
00:24:48,310 --> 00:24:46,480
means that the areas that

650
00:24:50,950 --> 00:24:48,320
the reason why the reasons are our

651
00:24:53,430 --> 00:24:50,960
regions are radar bright is because they

652
00:24:54,710 --> 00:24:53,440
in fact are composed dominantly of water

653
00:24:56,630 --> 00:24:54,720
ice

654
00:24:58,390 --> 00:24:56,640
the next graphic shows

655
00:24:59,269 --> 00:24:58,400
the mla

656
00:25:01,190 --> 00:24:59,279
or

657
00:25:03,669 --> 00:25:01,200
messenger laser excuse me mercury laser

658
00:25:05,750 --> 00:25:03,679
altimeter uh reflectivity measurements

659
00:25:09,029 --> 00:25:05,760
for these very same areas and you can

660
00:25:10,630 --> 00:25:09,039
see very clearly these uh dark regions

661
00:25:13,350 --> 00:25:10,640
that are associated with these impact

662
00:25:15,029 --> 00:25:13,360
craters when we first saw these uh

663
00:25:16,870 --> 00:25:15,039

measurements we started racking our

664
00:25:19,750 --> 00:25:16,880
brains about what could this mysterious

665
00:25:21,909 --> 00:25:19,760
dark material be we know basically two

666
00:25:23,669 --> 00:25:21,919
things about them one is that they're

667
00:25:26,310 --> 00:25:23,679
dark in fact they're very dark this

668
00:25:28,950 --> 00:25:26,320
material uh has the same reflectance as

669
00:25:31,110 --> 00:25:28,960
a lump of coal would be the second thing

670
00:25:33,909 --> 00:25:31,120
we know about them is that they are

671
00:25:35,590 --> 00:25:33,919
hanging out in these cool regions uh

672
00:25:37,830 --> 00:25:35,600
regions that have temperatures sort of

673
00:25:40,230 --> 00:25:37,840
less than the boiling point of water

674
00:25:42,789 --> 00:25:40,240
when we look around the solar system for

675
00:25:45,190 --> 00:25:42,799
materials that match this description

676
00:25:47,430 --> 00:25:45,200
the main type of material that shows up

677
00:25:49,909 --> 00:25:47,440
in our minds at least is the the concept

678
00:25:52,710 --> 00:25:49,919
that these are dark organic rich

679
00:25:54,470 --> 00:25:52,720
deposits when we look at comets or we

680
00:25:57,110 --> 00:25:54,480
look at icy bodies in the outer solar

681
00:25:59,909 --> 00:25:57,120
system we often find that these objects

682
00:26:02,230 --> 00:25:59,919
are extremely dark and spectroscopically

683
00:26:03,269 --> 00:26:02,240
we know that they are covered by this

684
00:26:06,549 --> 00:26:03,279
dark

685
00:26:07,750 --> 00:26:06,559
complex organic mix of materials

686
00:26:09,830 --> 00:26:07,760
this

687
00:26:11,669 --> 00:26:09,840
material we believe therefore was is

688
00:26:14,549 --> 00:26:11,679

also being deposited on mercury by the

689
00:26:16,630 --> 00:26:14,559
same types of objects and this organic

690
00:26:19,029 --> 00:26:16,640
material may be the same type of organic

691
00:26:21,909 --> 00:26:19,039
material that ultimately gave rise to

692
00:26:23,430 --> 00:26:21,919
life on earth originally

693
00:26:25,590 --> 00:26:23,440
one if you look at the graphic a little

694
00:26:28,149 --> 00:26:25,600
more carefully and the next slide uh

695
00:26:31,190 --> 00:26:28,159
shows that uh the interiors of some of

696
00:26:33,269 --> 00:26:31,200
these uh dark regions actually contain

697
00:26:35,190 --> 00:26:33,279
brighter material and the question is

698
00:26:35,990 --> 00:26:35,200
what could this material be

699
00:26:38,070 --> 00:26:36,000
um

700
00:26:40,230 --> 00:26:38,080
if you look very close closely at the

701
00:26:42,070 --> 00:26:40,240
locations of these spots and then go to

702
00:26:43,750 --> 00:26:42,080
the next graphic we show

703
00:26:46,149 --> 00:26:43,760
what the thermal model predicts in these

704
00:26:48,710 --> 00:26:46,159
particular areas and you can see that

705
00:26:52,470 --> 00:26:48,720
all of these bright areas both in their

706
00:26:55,190 --> 00:26:52,480
geographic extent uh and their size uh

707
00:26:57,269 --> 00:26:55,200
are uh show up as surface ice deposits

708
00:26:59,830 --> 00:26:57,279
in the uh in the in the uh

709
00:27:01,830 --> 00:26:59,840
in the uh thermal model results and this

710
00:27:03,430 --> 00:27:01,840
was for very gratifying for us because

711
00:27:05,830 --> 00:27:03,440
it means that we're definitely on the

712
00:27:07,430 --> 00:27:05,840
right track when we're saying that these

713
00:27:09,590 --> 00:27:07,440

deposits are made out of water ice

714
00:27:11,669 --> 00:27:09,600
because there's an exact match between

715
00:27:14,310 --> 00:27:11,679
the mla bright areas

716
00:27:16,789 --> 00:27:14,320
and the and the surface water rices that

717
00:27:18,710 --> 00:27:16,799
are predicted by the model

718
00:27:21,350 --> 00:27:18,720
the next graphic describes

719
00:27:23,190 --> 00:27:21,360
our general concept for how

720
00:27:24,950 --> 00:27:23,200
the mercury polar deposits got to be the

721
00:27:27,029 --> 00:27:24,960
way they are

722
00:27:29,510 --> 00:27:27,039
the craters at the high latitudes are

723
00:27:32,310 --> 00:27:29,520
illuminated obliquely by the sun

724
00:27:33,110 --> 00:27:32,320
the equator facing walls are very very

725
00:27:35,750 --> 00:27:33,120
hot

726
00:27:37,990 --> 00:27:35,760
as you move towards the

727
00:27:40,310 --> 00:27:38,000
forward facing walls

728
00:27:42,230 --> 00:27:40,320
they are in permanent shadow and are

729
00:27:44,389 --> 00:27:42,240
very very cold so there's an extreme

730
00:27:46,070 --> 00:27:44,399
thermal environment within each of these

731
00:27:48,470 --> 00:27:46,080
craters

732
00:27:50,789 --> 00:27:48,480
the next slide shows that

733
00:27:52,630 --> 00:27:50,799
there is a source of water and a range

734
00:27:54,950 --> 00:27:52,640
of other volatiles from

735
00:27:57,669 --> 00:27:54,960
objects impacting mercury as indicated

736
00:28:00,230 --> 00:27:57,679
by this comet here this material can hit

737
00:28:02,789 --> 00:28:00,240
at any latitude on mercury and then

738
00:28:05,029 --> 00:28:02,799

the volatiles migrate about the planet

739
00:28:08,149 --> 00:28:05,039
and eventually as shown in the next

740
00:28:10,070 --> 00:28:08,159
slide uh some fraction of them wind up

741
00:28:12,549 --> 00:28:10,080
in the polar regions that's as a

742
00:28:16,470 --> 00:28:12,559
heterogeneous mix of materials

743
00:28:19,029 --> 00:28:16,480
over time there is a migration of water

744
00:28:20,710 --> 00:28:19,039
ice from areas that are warmer into

745
00:28:23,430 --> 00:28:20,720
areas that are colder as shown in the

746
00:28:25,029 --> 00:28:23,440
next slide and this tends to concentrate

747
00:28:27,750 --> 00:28:25,039
the contaminants that were present in

748
00:28:30,710 --> 00:28:27,760
the water ice near the surface forming

749
00:28:33,269 --> 00:28:30,720
essentially a lag deposit over time as

750
00:28:35,590 --> 00:28:33,279
shown in the last slide

751
00:28:37,750 --> 00:28:35,600
this material darkens after exposure to

752
00:28:39,430 --> 00:28:37,760
the mercury space environment and we end

753
00:28:41,909 --> 00:28:39,440
up with the situation that we currently

754
00:28:44,230 --> 00:28:41,919
have dark deposits that

755
00:28:47,190 --> 00:28:44,240
cover the permanently shattered regions

756
00:28:49,669 --> 00:28:47,200
underlaying by water ice deposits and

757
00:28:51,750 --> 00:28:49,679
then finally in the very coldest places

758
00:28:52,950 --> 00:28:51,760
water ice deposits exposed on the

759
00:28:55,029 --> 00:28:52,960
surface

760
00:28:56,630 --> 00:28:55,039
now the most interesting thing about

761
00:28:58,789 --> 00:28:56,640
these deposits

762
00:29:01,350 --> 00:28:58,799
is that they appear to be in a very

763
00:29:03,350 --> 00:29:01,360

organized state in other words we find

764
00:29:04,789 --> 00:29:03,360
water ice exposed everywhere that it's

765
00:29:07,029 --> 00:29:04,799
cold enough for it to be and we find

766
00:29:09,029 --> 00:29:07,039
surf subsurface water ice every place

767
00:29:11,350 --> 00:29:09,039
that is cold enough for that to be for

768
00:29:12,870 --> 00:29:11,360
this situation to occur it cannot be the

769
00:29:15,110 --> 00:29:12,880
product of something that happened let's

770
00:29:17,750 --> 00:29:15,120
say billions of years ago in the ancient

771
00:29:19,350 --> 00:29:17,760
past but rather some process on mercury

772
00:29:20,950 --> 00:29:19,360
that is both delivering as well as

773
00:29:23,350 --> 00:29:20,960
redistributing

774
00:29:26,070 --> 00:29:23,360
these volatile materials and placing

775
00:29:27,590 --> 00:29:26,080
them in places that are thermally stable

776
00:29:30,310 --> 00:29:27,600
with that i'll turn it over to sean

777
00:29:32,389 --> 00:29:30,320
solomon for some concluding remarks

778
00:29:33,669 --> 00:29:32,399
let me take just a couple of minutes to

779
00:29:35,750 --> 00:29:33,679
tie together what you've heard here

780
00:29:37,909 --> 00:29:35,760
today

781
00:29:39,909 --> 00:29:37,919
one of the major objectives of the

782
00:29:42,789 --> 00:29:39,919
messenger mission when we were selected

783
00:29:45,190 --> 00:29:42,799
and when we launched was to test

784
00:29:48,310 --> 00:29:45,200
the idea more than 20 years

785
00:29:50,389 --> 00:29:48,320
old that the polar deposits on mercury

786
00:29:53,190 --> 00:29:50,399
discovered by earth-based radar consists

787
00:29:55,430 --> 00:29:53,200
dominantly of water ice they match the

788
00:29:59,269 --> 00:29:55,440

radar characteristics and we subjected

789
00:30:00,789 --> 00:29:59,279
that hypothesis to three very stringent

790
00:30:03,029 --> 00:30:00,799
tests

791
00:30:05,350 --> 00:30:03,039
does it have the neutron spectrometry

792
00:30:07,830 --> 00:30:05,360
signal that you would expect for water

793
00:30:09,430 --> 00:30:07,840
ice as you heard from david lawrence yes

794
00:30:12,070 --> 00:30:09,440
it does

795
00:30:14,389 --> 00:30:12,080
does it have the near infrared

796
00:30:17,029 --> 00:30:14,399
reflectance where exposed at the surface

797
00:30:20,070 --> 00:30:17,039
that you would expect for water ice as

798
00:30:23,430 --> 00:30:20,080
you heard from greg newman yes it does

799
00:30:25,909 --> 00:30:23,440
and finally does it match the very

800
00:30:28,149 --> 00:30:25,919
detailed thermal models that we can now

801
00:30:29,830 --> 00:30:28,159
construct on the basis of messenger

802
00:30:32,470 --> 00:30:29,840
measurements of the topography of the

803
00:30:34,710 --> 00:30:32,480
north polar region of mercury

804
00:30:37,190 --> 00:30:34,720
and match that to the thermodynamic

805
00:30:40,149 --> 00:30:37,200
characteristics of water ice and you

806
00:30:41,269 --> 00:30:40,159
heard from david page the answer is yes

807
00:30:44,230 --> 00:30:41,279
it does

808
00:30:46,950 --> 00:30:44,240
so water ice passed these three

809
00:30:49,510 --> 00:30:46,960
challenging tests and in fact

810
00:30:51,909 --> 00:30:49,520
we know of no other compound that

811
00:30:54,710 --> 00:30:51,919
matches the radar

812
00:30:56,789 --> 00:30:54,720
the neutron the reflectance and the

813
00:30:59,669 --> 00:30:56,799

thermal characteristics that we have

814
00:31:01,909 --> 00:30:59,679
documented with the messenger spacecraft

815
00:31:04,310 --> 00:31:01,919
so the hypothesis that these deposits

816
00:31:06,470 --> 00:31:04,320
are dominantly water ice with an

817
00:31:08,310 --> 00:31:06,480
interesting darker component

818
00:31:10,950 --> 00:31:08,320
covering them

819
00:31:12,549 --> 00:31:10,960
has survived these very challenging

820
00:31:14,630 --> 00:31:12,559
tests

821
00:31:16,470 --> 00:31:14,640
so most broadly

822
00:31:19,350 --> 00:31:16,480
let me conclude by saying that that

823
00:31:20,310 --> 00:31:19,360
messenger has uh revealed a very

824
00:31:23,509 --> 00:31:20,320
important

825
00:31:25,830 --> 00:31:23,519
chapter in the story of how water ice

826
00:31:28,149 --> 00:31:25,840
and other volatile materials have been

827
00:31:29,350 --> 00:31:28,159
delivered to the inner planets including

828
00:31:32,070 --> 00:31:29,360
mercury

829
00:31:35,830 --> 00:31:32,080
we think by the impact of comets over

830
00:31:38,230 --> 00:31:35,840
time and of all rich asteroids

831
00:31:40,549 --> 00:31:38,240
it's extraordinary that this

832
00:31:42,710 --> 00:31:40,559
chapter is so well preserved on the

833
00:31:45,190 --> 00:31:42,720
planet closest to the sun

834
00:31:47,669 --> 00:31:45,200
and and that is the result of the

835
00:31:49,110 --> 00:31:47,679
extreme stability of the cold

836
00:31:49,830 --> 00:31:49,120
temperatures

837
00:31:51,669 --> 00:31:49,840
in

838
00:31:54,389 --> 00:31:51,679

mercury's permanently shadowed regions

839
00:31:57,509 --> 00:31:54,399
that are stabilized by the

840
00:31:59,190 --> 00:31:57,519
also extraordinarily stable spin state

841
00:32:01,830 --> 00:31:59,200
of the innermost planet which is in a

842
00:32:04,950 --> 00:32:01,840
spin-over resonance and an orbit that

843
00:32:07,029 --> 00:32:04,960
that favors uh the stability of these

844
00:32:09,669 --> 00:32:07,039
deep coal traps

845
00:32:12,389 --> 00:32:09,679
so in the broadest sense this chapter uh

846
00:32:14,310 --> 00:32:12,399
red on mercury and one which we on the

847
00:32:16,630 --> 00:32:14,320
messenger team hope to pursue in greater

848
00:32:18,310 --> 00:32:16,640
detail over the months ahead

849
00:32:19,350 --> 00:32:18,320
uh is telling us

850
00:32:21,110 --> 00:32:19,360
about

851
00:32:23,509 --> 00:32:21,120
the delivery of water

852
00:32:26,070 --> 00:32:23,519
and the delivery of some of the complex

853
00:32:27,430 --> 00:32:26,080
organic building blocks on our own

854
00:32:30,310 --> 00:32:27,440
planet

855
00:32:32,310 --> 00:32:30,320
and it it behooves us to understand this

856
00:32:34,549 --> 00:32:32,320
particular chapter on the innermost

857
00:32:35,990 --> 00:32:34,559
planet as well as we can

858
00:32:38,310 --> 00:32:36,000
thank you dwayne

859
00:32:39,509 --> 00:32:38,320
well thank you okay now we're going to

860
00:32:40,549 --> 00:32:39,519
open up for questions and we're going to

861
00:32:42,389 --> 00:32:40,559
do something a little different here

862
00:32:44,950 --> 00:32:42,399
this afternoon

863
00:32:47,830 --> 00:32:44,960

clearly this is a media briefing the

864
00:32:51,590 --> 00:32:47,840
media have a lot of stories already but

865
00:32:54,630 --> 00:32:51,600
we also have a tremendous opportunity to

866
00:32:56,549 --> 00:32:54,640
directly talk to the public via social

867
00:32:59,110 --> 00:32:56,559
media twitter facebook

868
00:33:01,269 --> 00:32:59,120
google plus and nasa has a tremendous

869
00:33:03,350 --> 00:33:01,279
following and they're following the

870
00:33:05,990 --> 00:33:03,360
conversation and again join the

871
00:33:07,669 --> 00:33:06,000
conversation at hashtag ask nasa so

872
00:33:09,909 --> 00:33:07,679
we're going to take questions directly

873
00:33:12,070 --> 00:33:09,919
from the public i'm also being told that

874
00:33:13,909 --> 00:33:12,080
we have lots of students watching this

875
00:33:15,269 --> 00:33:13,919
the young folks and i've jotted down

876
00:33:17,110 --> 00:33:15,279
some of the questions a couple of them

877
00:33:18,950 --> 00:33:17,120
for you sean and the team and one for

878
00:33:21,029 --> 00:33:18,960
jim green and we'll start there and then

879
00:33:22,310 --> 00:33:21,039
we have any media on the phone we'll go

880
00:33:23,590 --> 00:33:22,320
to them so we're going to go directly to

881
00:33:24,950 --> 00:33:23,600
the public here

882
00:33:26,789 --> 00:33:24,960
let me start with the first one here for

883
00:33:30,470 --> 00:33:26,799
you sean um

884
00:33:37,350 --> 00:33:33,190
well uh we've got a

885
00:33:39,029 --> 00:33:37,360
very broad menu of a targeted high

886
00:33:40,389 --> 00:33:39,039
resolution observations we certainly

887
00:33:41,509 --> 00:33:40,399
want to follow up on what you heard

888
00:33:44,710 --> 00:33:41,519

about today

889
00:33:46,630 --> 00:33:44,720
uh the north polar regions and uh

890
00:33:49,110 --> 00:33:46,640
the bright deposits the dark deposits

891
00:33:53,269 --> 00:33:49,120
what they mean what the

892
00:33:55,430 --> 00:33:53,279
uh images we can acquire uh of the areas

893
00:33:57,269 --> 00:33:55,440
just adjacent to those uh regions in

894
00:33:59,269 --> 00:33:57,279
permanent shadow whether there are any

895
00:34:02,070 --> 00:33:59,279
chemical or morphological signatures of

896
00:34:03,909 --> 00:34:02,080
unusual phenomena there but mercury

897
00:34:05,909 --> 00:34:03,919
displays a host of very interesting

898
00:34:07,590 --> 00:34:05,919
phenomena that we

899
00:34:09,349 --> 00:34:07,600
have been talking about and writing

900
00:34:11,750 --> 00:34:09,359
about for a year and a half

901
00:34:14,790 --> 00:34:11,760
its magnetic field its

902
00:34:17,109 --> 00:34:14,800
extraordinarily dynamic atmosphere its

903
00:34:18,629 --> 00:34:17,119
wonderfully complex complex geological

904
00:34:21,270 --> 00:34:18,639
history some of which

905
00:34:23,909 --> 00:34:21,280
has a record of the loss of volatile

906
00:34:25,270 --> 00:34:23,919
materials to space creating landforms

907
00:34:27,109 --> 00:34:25,280
that are seen on mercury and not seen

908
00:34:29,430 --> 00:34:27,119
elsewhere we want to understand the

909
00:34:30,950 --> 00:34:29,440
chemical and the geological origins of

910
00:34:32,069 --> 00:34:30,960
those features so

911
00:34:35,190 --> 00:34:32,079
we've got a

912
00:34:36,470 --> 00:34:35,200
long menu of detailed observations that

913
00:34:37,589 --> 00:34:36,480

we're planning over the next several

914
00:34:39,750 --> 00:34:37,599
months

915
00:34:41,669 --> 00:34:39,760
we hope to continue observations well

916
00:34:43,589 --> 00:34:41,679
into next year

917
00:34:46,069 --> 00:34:43,599
next year will mark

918
00:34:47,909 --> 00:34:46,079
solar maximum the maximum and the

919
00:34:51,109 --> 00:34:47,919
activity of the sun

920
00:34:53,030 --> 00:34:51,119
that follows an 11-year cycle because

921
00:34:57,589 --> 00:34:53,040
mercury is the planet closest to the sun

922
00:34:59,829 --> 00:34:57,599
it is also the most dynamic planet

923
00:35:01,510 --> 00:34:59,839
in its response to changes in solar

924
00:35:04,550 --> 00:35:01,520
activity to

925
00:35:06,230 --> 00:35:04,560
solar storms to the streams of energetic

926
00:35:08,470 --> 00:35:06,240
particles that are thrown out from the

927
00:35:10,470 --> 00:35:08,480
sun to the extremes of radiation that

928
00:35:12,550 --> 00:35:10,480
are thrown out from the sun during many

929
00:35:14,150 --> 00:35:12,560
of these storms so mercury has a front

930
00:35:16,150 --> 00:35:14,160
row seat and as long as messenger is

931
00:35:18,390 --> 00:35:16,160
taking data messenger will have a front

932
00:35:21,589 --> 00:35:18,400
row seat as well so stay tuned there are

933
00:35:23,190 --> 00:35:21,599
a lot of new observations to come

934
00:35:25,030 --> 00:35:23,200
and we're going to continue taking

935
00:35:27,910 --> 00:35:25,040
questions from our social media and

936
00:35:30,790 --> 00:35:27,920
again join the conversation twitter

937
00:35:32,630 --> 00:35:30,800
google plus facebook and others at

938
00:35:33,589 --> 00:35:32,640

twitter

939
00:35:35,910 --> 00:35:33,599
ask

940
00:35:38,790 --> 00:35:35,920
nasa and we'll get to the phone lines to

941
00:35:41,109 --> 00:35:38,800
the media but again we're going to

942
00:35:42,550 --> 00:35:41,119
let the public and the students directly

943
00:35:44,470 --> 00:35:42,560
talk to these

944
00:35:47,109 --> 00:35:44,480
uh the messenger team and their

945
00:35:48,630 --> 00:35:47,119
incredible work they're doing so sean

946
00:35:50,390 --> 00:35:48,640
and for the team remember here's a fun

947
00:35:53,510 --> 00:35:50,400
one here how would you describe is this

948
00:35:56,550 --> 00:35:53,520
a period or exclamation point

949
00:35:59,270 --> 00:35:56,560
on the finding and if there's water ice

950
00:36:02,310 --> 00:35:59,280
what does this say about

951
00:36:04,150 --> 00:36:02,320
life in the solar system

952
00:36:06,950 --> 00:36:04,160
where there's water

953
00:36:16,550 --> 00:36:06,960
they say there may be life

954
00:36:21,109 --> 00:36:19,030
yeah the more we more we examine the

955
00:36:22,630 --> 00:36:21,119
solar system the more we realize it's a

956
00:36:25,030 --> 00:36:22,640
soggy place

957
00:36:26,790 --> 00:36:25,040
and that that's really quite exciting

958
00:36:28,150 --> 00:36:26,800
because that means

959
00:36:31,349 --> 00:36:28,160
you know the amount of water that we

960
00:36:33,030 --> 00:36:31,359
have here on earth that was a

961
00:36:34,870 --> 00:36:33,040
nominally inherent when it was

962
00:36:37,109 --> 00:36:34,880
originally formed but probably brought

963
00:36:38,550 --> 00:36:37,119

here that water and other volatiles were

964
00:36:41,270 --> 00:36:38,560
brought to many other places in the

965
00:36:43,510 --> 00:36:41,280
solar system so it really bodes well for

966
00:36:45,190 --> 00:36:43,520
us to continue on the exploration

967
00:36:46,710 --> 00:36:45,200
following the water

968
00:36:48,870 --> 00:36:46,720
and its signs throughout the solar

969
00:36:50,950 --> 00:36:48,880
system

970
00:36:53,829 --> 00:36:50,960
to answer the first question i would my

971
00:36:55,349 --> 00:36:53,839
own choice for punctuation mark on the

972
00:36:56,150 --> 00:36:55,359
story today would be an exclamation

973
00:36:58,870 --> 00:36:56,160
point

974
00:37:01,510 --> 00:36:58,880
but i'll ask my colleagues to

975
00:37:03,030 --> 00:37:01,520
we would all agree um if not only for

976
00:37:05,589 --> 00:37:03,040
the exciting results the amount of work

977
00:37:07,670 --> 00:37:05,599
that was put into this in terms of

978
00:37:09,190 --> 00:37:07,680
the effort of so many people

979
00:37:10,950 --> 00:37:09,200
on the messenger project not only

980
00:37:13,349 --> 00:37:10,960
putting the instruments together

981
00:37:15,109 --> 00:37:13,359
but doing the analysis it's an absolute

982
00:37:17,270 --> 00:37:15,119
exclamation point with the excitement

983
00:37:19,829 --> 00:37:17,280
that we have of being able to have these

984
00:37:22,710 --> 00:37:19,839
results and as sean said they're

985
00:37:26,069 --> 00:37:22,720
difficult challenging results and to

986
00:37:27,589 --> 00:37:26,079
have them all come together in this way

987
00:37:30,150 --> 00:37:27,599
was using an analogy earlier it's kind

988
00:37:31,670 --> 00:37:30,160

of like a a key that you get the right

989
00:37:33,270 --> 00:37:31,680
key it gets into the lock it turns and

990
00:37:34,950 --> 00:37:33,280
the door opens and

991
00:37:37,270 --> 00:37:34,960
all the results are pointing to the same

992
00:37:38,710 --> 00:37:37,280
place and that's that's definitely an

993
00:37:43,510 --> 00:37:38,720
exclamation point

994
00:37:46,310 --> 00:37:43,520
never expected to see this new wrinkle

995
00:37:48,069 --> 00:37:46,320
of dark organic rich materials

996
00:37:49,510 --> 00:37:48,079
in places where we were looking for

997
00:37:51,750 --> 00:37:49,520
water ice

998
00:37:53,910 --> 00:37:51,760
that was astounding and

999
00:37:56,550 --> 00:37:53,920
we didn't expect the results to be so

1000
00:38:00,470 --> 00:37:56,560
clear but the thermal models

1001
00:38:02,630 --> 00:38:00,480
certainly made them an explanation

1002
00:38:07,510 --> 00:38:02,640
yeah it's very rare we get such good

1003
00:38:13,109 --> 00:38:10,470
we'll take this one let me be clear that

1004
00:38:14,150 --> 00:38:13,119
no one is saying that there is life on

1005
00:38:17,030 --> 00:38:14,160
mercury

1006
00:38:20,710 --> 00:38:17,040
nonetheless nonetheless the history of

1007
00:38:24,550 --> 00:38:20,720
life begins with the delivery to

1008
00:38:26,870 --> 00:38:24,560
some home object of water and of the

1009
00:38:29,030 --> 00:38:26,880
building blocks the organic building box

1010
00:38:30,950 --> 00:38:29,040
that must undergo some kind of chemistry

1011
00:38:34,390 --> 00:38:30,960
which we still don't understand on our

1012
00:38:36,630 --> 00:38:34,400
own planet and so to capture the early

1013
00:38:40,310 --> 00:38:36,640

phases of these processes on another

1014
00:38:42,630 --> 00:38:40,320
solar system body gives us a window into

1015
00:38:45,109 --> 00:38:42,640
the importance of these early processes

1016
00:38:47,390 --> 00:38:45,119
even on our own planet and so

1017
00:38:49,910 --> 00:38:47,400
mercury is becoming an object of

1018
00:38:52,630 --> 00:38:49,920
astrobiological interest where it wasn't

1019
00:38:54,550 --> 00:38:52,640
much of one before um

1020
00:38:56,710 --> 00:38:54,560
that's not to say that we expect to find

1021
00:39:00,390 --> 00:38:56,720
any life forms i don't think anybody on

1022
00:39:02,390 --> 00:39:00,400
this table does but in terms of the

1023
00:39:05,270 --> 00:39:02,400
book of life there is some early

1024
00:39:08,710 --> 00:39:05,280
chapters and mercury may indeed inform

1025
00:39:10,230 --> 00:39:08,720
us about what's in those chapters

1026
00:39:12,150 --> 00:39:10,240
sean i'm glad you explained that because

1027
00:39:15,430 --> 00:39:12,160
on the twitter you just answered about

1028
00:39:17,109 --> 00:39:15,440
30 questions

1029
00:39:19,589 --> 00:39:17,119
life and water so

1030
00:39:21,910 --> 00:39:19,599
let me let me toss this question to dr

1031
00:39:25,030 --> 00:39:21,920
green

1032
00:39:27,430 --> 00:39:25,040
have

1033
00:39:29,430 --> 00:39:27,440
had a lot of success as your division

1034
00:39:31,430 --> 00:39:29,440
mars missions grail cassini of course

1035
00:39:33,990 --> 00:39:31,440
messenger what is your recipe for

1036
00:39:37,270 --> 00:39:35,270
well

1037
00:39:39,109 --> 00:39:37,280
working with the community has just been

1038
00:39:40,230 --> 00:39:39,119

a really delight

1039
00:39:43,430 --> 00:39:40,240
the

1040
00:39:45,430 --> 00:39:43,440
years

1041
00:39:47,349 --> 00:39:45,440
they're well focused

1042
00:39:49,349 --> 00:39:47,359
they're dedicated

1043
00:39:51,910 --> 00:39:49,359
we have a cadre of engineers that are

1044
00:39:53,670 --> 00:39:51,920
just tremendously supportive combine

1045
00:39:55,670 --> 00:39:53,680
that with the expertise that have been

1046
00:39:57,750 --> 00:39:55,680
developed at our centers and it's a

1047
00:39:59,430 --> 00:39:57,760
winning combination

1048
00:40:02,710 --> 00:39:59,440
you know it's very hard to do these

1049
00:40:05,030 --> 00:40:02,720
missions on time and on schedule but

1050
00:40:07,190 --> 00:40:05,040
we have a couple things going for us one

1051
00:40:08,710 --> 00:40:07,200
is a planetary window

1052
00:40:10,790 --> 00:40:08,720
you know and that's a blessing and a

1053
00:40:12,630 --> 00:40:10,800
curse the the blessing part of it is

1054
00:40:13,910 --> 00:40:12,640
we've got to get things done

1055
00:40:15,750 --> 00:40:13,920
enabled

1056
00:40:18,470 --> 00:40:15,760
to be launched on time and in that

1057
00:40:20,870 --> 00:40:18,480
window the curse is uh well it's a big

1058
00:40:23,589 --> 00:40:20,880
problem financially if we miss it so we

1059
00:40:25,270 --> 00:40:23,599
all are dedicated to work very hard

1060
00:40:27,750 --> 00:40:25,280
to be able to meet those planetary

1061
00:40:30,069 --> 00:40:27,760
windows and uh and because of that the

1062
00:40:32,550 --> 00:40:30,079
program indeed has been quite successful

1063
00:40:35,030 --> 00:40:32,560

over the years

1064
00:40:37,349 --> 00:40:35,040
before i ask the next question i want uh

1065
00:40:39,270 --> 00:40:37,359
before we end here i've got uh looks

1066
00:40:41,349 --> 00:40:39,280
like classrooms for the midwest but they

1067
00:40:42,470 --> 00:40:41,359
they want me to ask each of you to

1068
00:40:44,390 --> 00:40:42,480
explain

1069
00:40:46,790 --> 00:40:44,400
uh how did you get into your respective

1070
00:40:48,069 --> 00:40:46,800
field and any advice you can have for

1071
00:40:49,030 --> 00:40:48,079
students but we'll say that for less

1072
00:40:51,190 --> 00:40:49,040
because we're going to go right down the

1073
00:40:54,069 --> 00:40:51,200
line but the next question

1074
00:40:56,150 --> 00:40:54,079
uh in shadow icy areas could it be that

1075
00:40:57,750 --> 00:40:56,160
around the fringes of the ice

1076
00:41:01,270 --> 00:40:57,760
they're just conditions that are right

1077
00:41:05,670 --> 00:41:03,829
i can take that question

1078
00:41:07,430 --> 00:41:05,680
there are certainly temperatures that

1079
00:41:09,030 --> 00:41:07,440
are conducive to liquid water but the

1080
00:41:11,270 --> 00:41:09,040
problem with mercury is it doesn't have

1081
00:41:13,030 --> 00:41:11,280
an atmosphere so if you could create a

1082
00:41:16,069 --> 00:41:13,040
little puddle of liquid water in these

1083
00:41:17,990 --> 00:41:16,079
areas the molecules of water would

1084
00:41:20,550 --> 00:41:18,000
evaporate off and fly off at all

1085
00:41:22,470 --> 00:41:20,560
directions and eventually very rapidly

1086
00:41:24,950 --> 00:41:22,480
in fact you would have no more liquid

1087
00:41:28,390 --> 00:41:24,960
water so while you could have metastable

1088
00:41:31,510 --> 00:41:28,400

liquid water uh it wouldn't be like a

1089
00:41:33,430 --> 00:41:31,520
pond or a wet soggy uh subsurface area

1090
00:41:35,270 --> 00:41:33,440
at all at mercury it would it would just

1091
00:41:37,990 --> 00:41:35,280
turn to ice or turn into vapor there'd

1092
00:41:40,069 --> 00:41:38,000
be no no liquid

1093
00:41:43,109 --> 00:41:40,079
okay again i want to thank you all for

1094
00:41:44,390 --> 00:41:43,119
joining the the the conversation here

1095
00:41:48,630 --> 00:41:44,400
ask

1096
00:41:50,790 --> 00:41:48,640
conversation twitter

1097
00:41:52,470 --> 00:41:50,800
google plus facebook and the next

1098
00:41:54,630 --> 00:41:52,480
question

1099
00:41:56,150 --> 00:41:54,640
let's see does the measurement

1100
00:41:58,790 --> 00:41:56,160
method

1101
00:42:02,710 --> 00:41:58,800
used by messenger to detect hydrogen

1102
00:42:05,270 --> 00:42:02,720
allow the determination of isotopic

1103
00:42:08,550 --> 00:42:05,280
isotopic distribution of hydrogen

1104
00:42:12,550 --> 00:42:09,670
basically

1105
00:42:15,270 --> 00:42:12,560
that's the answer but we're measuring uh

1106
00:42:16,950 --> 00:42:15,280
hydrogen atoms and

1107
00:42:19,109 --> 00:42:16,960
that's what we're able to tell we can't

1108
00:42:20,710 --> 00:42:19,119
get into those type of details of

1109
00:42:22,710 --> 00:42:20,720
isotopes

1110
00:42:24,950 --> 00:42:22,720
and so it's really just it's a basic

1111
00:42:27,589 --> 00:42:24,960
story of

1112
00:42:29,510 --> 00:42:27,599
billiard ball physics and what we

1113
00:42:31,349 --> 00:42:29,520

measure is neutrons when they hit a

1114
00:42:33,349 --> 00:42:31,359
hydrogen atom just like when you're

1115
00:42:36,230 --> 00:42:33,359
playing billiards and the cue ball dies

1116
00:42:38,150 --> 00:42:36,240
when you get a dead-on hit and that's

1117
00:42:39,750 --> 00:42:38,160
that's what we're measuring and we count

1118
00:42:44,390 --> 00:42:39,760
neutrons and when there's not as many of

1119
00:42:48,230 --> 00:42:46,630
sean i think you you answer this is that

1120
00:42:49,750 --> 00:42:48,240
uh so we keep discovering new places the

1121
00:42:51,270 --> 00:42:49,760
same to hold water can we now say that

1122
00:42:54,630 --> 00:42:51,280
water is actually quite common in the

1123
00:43:00,309 --> 00:42:57,270
you jim you want to i didn't answer that

1124
00:43:04,069 --> 00:43:00,319
uh directly but

1125
00:43:07,030 --> 00:43:04,079
the most likely source for the

1126
00:43:08,390 --> 00:43:07,040
polar deposits which have passed all the

1127
00:43:09,910 --> 00:43:08,400
tests for

1128
00:43:11,510 --> 00:43:09,920
uh

1129
00:43:13,510 --> 00:43:11,520
a composition that's dominantly water

1130
00:43:15,910 --> 00:43:13,520
ice the most likely source for that

1131
00:43:17,109 --> 00:43:15,920
water is actually pretty far from

1132
00:43:20,550 --> 00:43:17,119
mercury

1133
00:43:23,510 --> 00:43:20,560
it is the source region of comets and

1134
00:43:25,430 --> 00:43:23,520
ice and volatile rich asteroids

1135
00:43:27,109 --> 00:43:25,440
namely the outer solar system

1136
00:43:28,790 --> 00:43:27,119
and so

1137
00:43:30,710 --> 00:43:28,800
water is indeed

1138
00:43:34,230 --> 00:43:30,720

a common uh

1139
00:43:36,230 --> 00:43:34,240
component of our solar system it's

1140
00:43:37,430 --> 00:43:36,240
that's a big component of the ice giant

1141
00:43:40,390 --> 00:43:37,440
planets

1142
00:43:42,150 --> 00:43:40,400
it covers many of the satellites of the

1143
00:43:44,150 --> 00:43:42,160
major planets

1144
00:43:47,670 --> 00:43:44,160
and it is expected to be a constituent

1145
00:43:49,670 --> 00:43:47,680
of many of the small objects

1146
00:43:51,190 --> 00:43:49,680
that are

1147
00:43:53,589 --> 00:43:51,200
in the outer solar system beyond the

1148
00:43:55,750 --> 00:43:53,599
main asteroid belt and extending out

1149
00:43:58,390 --> 00:43:55,760
beyond the uh

1150
00:44:00,390 --> 00:43:58,400
orbit of the most distant planet

1151
00:44:02,069 --> 00:44:00,400
so there's a lot of water out there as

1152
00:44:04,230 --> 00:44:02,079
there is a lot of water around other

1153
00:44:06,790 --> 00:44:04,240
stars

1154
00:44:09,109 --> 00:44:06,800
but at substantial distance and what

1155
00:44:11,030 --> 00:44:09,119
these observations at mercury tell us

1156
00:44:15,190 --> 00:44:11,040
and what our own thinking about the

1157
00:44:17,990 --> 00:44:15,200
earth has has made us uh

1158
00:44:19,910 --> 00:44:18,000
imagine before

1159
00:44:22,150 --> 00:44:19,920
there are mechanisms for

1160
00:44:24,550 --> 00:44:22,160
perturbing the orbits of comets and

1161
00:44:26,710 --> 00:44:24,560
asteroids that have operated over the

1162
00:44:27,670 --> 00:44:26,720
entire history of the solar system and

1163
00:44:29,990 --> 00:44:27,680

so

1164
00:44:32,630 --> 00:44:30,000
the history of water on our planet and

1165
00:44:33,670 --> 00:44:32,640
the history of water ice

1166
00:44:35,430 --> 00:44:33,680
on

1167
00:44:38,470 --> 00:44:35,440
mercury

1168
00:44:41,190 --> 00:44:38,480
are very much also the history of uh

1169
00:44:43,030 --> 00:44:41,200
interactions of comets and asteroids

1170
00:44:45,109 --> 00:44:43,040
with the inner solar system

1171
00:44:47,349 --> 00:44:45,119
so uh there is

1172
00:44:48,710 --> 00:44:47,359
uh water in the inner solar system and

1173
00:44:51,109 --> 00:44:48,720
that

1174
00:44:53,510 --> 00:44:51,119
we experience here on this planet often

1175
00:44:56,309 --> 00:44:53,520
um but uh

1176
00:44:58,390 --> 00:44:56,319
a lot of our water we now suspect uh

1177
00:44:59,829 --> 00:44:58,400
just as uh

1178
00:45:03,030 --> 00:44:59,839
the material that's likely to be water

1179
00:45:05,910 --> 00:45:03,040
ice on mercury uh originated uh at a

1180
00:45:06,870 --> 00:45:05,920
different part of the solar system

1181
00:45:08,550 --> 00:45:06,880
okay

1182
00:45:09,910 --> 00:45:08,560
i want to tell our audience out there

1183
00:45:12,470 --> 00:45:09,920
and thank you for sending questions and

1184
00:45:15,750 --> 00:45:12,480
joining the conversation hashtag

1185
00:45:17,589 --> 00:45:15,760
ask nasa we are going to take just i'm

1186
00:45:19,510 --> 00:45:17,599
going to take do a couple of more

1187
00:45:21,510 --> 00:45:19,520
questions and then i promised the

1188
00:45:23,270 --> 00:45:21,520

students that are watching that that you

1189
00:45:25,670 --> 00:45:23,280
would hear from the individuals on on

1190
00:45:27,750 --> 00:45:25,680
how they got started in this and and any

1191
00:45:29,990 --> 00:45:27,760
uh personal recommendations on guidance

1192
00:45:32,550 --> 00:45:30,000
but this question is for jim dr green

1193
00:45:33,510 --> 00:45:32,560
jim does nasa have plans for a mercury

1194
00:45:35,430 --> 00:45:33,520
lander

1195
00:45:37,910 --> 00:45:35,440
anytime soon

1196
00:45:40,230 --> 00:45:37,920
that's a good question um

1197
00:45:42,710 --> 00:45:40,240
you know landing on mercury and actually

1198
00:45:45,109 --> 00:45:42,720
tasting the water that would be the

1199
00:45:47,109 --> 00:45:45,119
confirmation of what we would seek in

1200
00:45:49,190 --> 00:45:47,119
the next step of doing this would be an

1201
00:45:50,710 --> 00:45:49,200
incredibly difficult but an incredibly

1202
00:45:53,109 --> 00:45:50,720
exciting mission

1203
00:45:56,309 --> 00:45:53,119
we have opportunities for the community

1204
00:45:57,430 --> 00:45:56,319
to be able to consider that a plan and

1205
00:45:59,750 --> 00:45:57,440
build that

1206
00:46:01,349 --> 00:45:59,760
through a competitive process and that

1207
00:46:03,349 --> 00:46:01,359
once again would be

1208
00:46:05,109 --> 00:46:03,359
our discovery program

1209
00:46:07,510 --> 00:46:05,119
so uh perhaps

1210
00:46:10,390 --> 00:46:07,520
uh the student that uh put in that

1211
00:46:12,150 --> 00:46:10,400
question would be in in line in later

1212
00:46:15,109 --> 00:46:12,160
years to be part of that team and let's

1213
00:46:16,950 --> 00:46:15,119

hope so

1214
00:46:19,589 --> 00:46:16,960
okay so i'm going to use this time for

1215
00:46:22,069 --> 00:46:19,599
the students uh jim since the camera's

1216
00:46:24,470 --> 00:46:22,079
on you just how did you get involved in

1217
00:46:25,750 --> 00:46:24,480
your field and any guidance for not just

1218
00:46:27,829 --> 00:46:25,760
middle school students but we have lots

1219
00:46:29,910 --> 00:46:27,839
of high school students watching also

1220
00:46:32,390 --> 00:46:29,920
well i grew up of course in the apollo

1221
00:46:34,470 --> 00:46:32,400
era in the early star trek and you know

1222
00:46:37,349 --> 00:46:34,480
so there was quite a bit of of interest

1223
00:46:39,109 --> 00:46:37,359
in space but what really got me started

1224
00:46:40,550 --> 00:46:39,119
turns out to be in high school when i

1225
00:46:43,910 --> 00:46:40,560
had an opportunity to look through a

1226
00:46:46,470 --> 00:46:43,920
telescope and actually get involved in

1227
00:46:48,790 --> 00:46:46,480
being part of an observatory

1228
00:46:50,710 --> 00:46:48,800
and that was just tremendously exciting

1229
00:46:52,790 --> 00:46:50,720
i built instruments for the telescope

1230
00:46:54,550 --> 00:46:52,800
that i used which was a 12-inch album

1231
00:46:56,150 --> 00:46:54,560
clark refractor and so when i left high

1232
00:46:57,589 --> 00:46:56,160
school i knew exactly what i wanted to

1233
00:46:59,990 --> 00:46:57,599
do and that was to get a degree in

1234
00:47:02,309 --> 00:47:00,000
astronomy so i went in university of

1235
00:47:04,870 --> 00:47:02,319
iowa and at that time they were on their

1236
00:47:06,790 --> 00:47:04,880
54th instrument on a spacecraft and i

1237
00:47:09,270 --> 00:47:06,800
thought this is absolutely fantastic to

1238
00:47:11,349 --> 00:47:09,280

do astronomy from spacecraft what a

1239
00:47:13,670 --> 00:47:11,359
great idea and i just got into the the

1240
00:47:16,309 --> 00:47:13,680
space field from that

1241
00:47:18,390 --> 00:47:16,319
but uh what it does take to be able to

1242
00:47:21,829 --> 00:47:18,400
hang in there and get your degree

1243
00:47:24,790 --> 00:47:21,839
uh and and um follow through and become

1244
00:47:27,270 --> 00:47:24,800
a phd

1245
00:47:29,670 --> 00:47:27,280
get your phd in that respect

1246
00:47:31,670 --> 00:47:29,680
not only is an interest and drive for

1247
00:47:34,390 --> 00:47:31,680
mathematics and and

1248
00:47:36,630 --> 00:47:34,400
and a love of the science but it really

1249
00:47:38,790 --> 00:47:36,640
takes determination

1250
00:47:40,549 --> 00:47:38,800
i can't underestimate how how important

1251
00:47:42,870 --> 00:47:40,559
determination has been in my career to

1252
00:47:44,549 --> 00:47:42,880
be able to get me to the next step

1253
00:47:46,549 --> 00:47:44,559
sean

1254
00:47:49,750 --> 00:47:46,559
i started out as a

1255
00:47:51,990 --> 00:47:49,760
as an earth scientist as a

1256
00:47:53,349 --> 00:47:52,000
a student of our own planet

1257
00:47:55,910 --> 00:47:53,359
using

1258
00:47:59,270 --> 00:47:55,920
geophysical tools like seismology

1259
00:48:00,710 --> 00:47:59,280
when i was an undergraduate

1260
00:48:02,790 --> 00:48:00,720
the very first

1261
00:48:06,630 --> 00:48:02,800
spacecraft to send

1262
00:48:10,950 --> 00:48:09,030
did so and

1263
00:48:13,270 --> 00:48:10,960

i happened to be in an institution where

1264
00:48:15,750 --> 00:48:13,280
the images were shown in real time as

1265
00:48:18,950 --> 00:48:15,760
they were received and in those days

1266
00:48:21,910 --> 00:48:18,960
it showed up on a video screen one line

1267
00:48:23,910 --> 00:48:21,920
at a time it's very very slow

1268
00:48:27,829 --> 00:48:23,920
but we're going back well one line at a

1269
00:48:29,990 --> 00:48:27,839
time the cratered surface of the ancient

1270
00:48:32,549 --> 00:48:30,000
southern uplands of mars

1271
00:48:34,150 --> 00:48:32,559
were revealed by just a handful of

1272
00:48:36,950 --> 00:48:34,160
images that were sent back by the marine

1273
00:48:39,349 --> 00:48:36,960
force spacecraft but that was that was a

1274
00:48:41,030 --> 00:48:39,359
captivating event for me and so even

1275
00:48:42,390 --> 00:48:41,040
though i remained an earth scientist

1276
00:48:43,910 --> 00:48:42,400
when the opportunity to work on

1277
00:48:45,990 --> 00:48:43,920
planetary missions came along at

1278
00:48:48,950 --> 00:48:46,000
different stages in my career i was

1279
00:48:49,990 --> 00:48:48,960
eager to join in

1280
00:48:54,630 --> 00:48:50,000
david

1281
00:48:56,549 --> 00:48:54,640
okay well uh as with you jim i'm uh

1282
00:48:59,349 --> 00:48:56,559
grew up excited by apollo but i'm a bit

1283
00:49:00,630 --> 00:48:59,359
younger than you so i was a

1284
00:49:02,870 --> 00:49:00,640
young kid

1285
00:49:04,470 --> 00:49:02,880
for apollo 17

1286
00:49:06,069 --> 00:49:04,480
but at the time that was still very

1287
00:49:08,150 --> 00:49:06,079
exciting i wanted to grow up and be an

1288
00:49:10,150 --> 00:49:08,160

astronaut but unfortunately my eyes are

1289
00:49:12,549 --> 00:49:10,160
kind of blurry like the neutrons and so

1290
00:49:14,390 --> 00:49:12,559
that's not a possibility

1291
00:49:17,190 --> 00:49:14,400
and so talking to people they said go

1292
00:49:19,349 --> 00:49:17,200
into science go into physics and so i

1293
00:49:21,030 --> 00:49:19,359
went into physics and

1294
00:49:22,870 --> 00:49:21,040
you know the astronaut thing didn't work

1295
00:49:25,109 --> 00:49:22,880
out and i think my wife is probably

1296
00:49:27,030 --> 00:49:25,119
pretty happy about that

1297
00:49:29,430 --> 00:49:27,040
but doing the science has been very

1298
00:49:31,349 --> 00:49:29,440
exciting and having this privilege to be

1299
00:49:33,109 --> 00:49:31,359
part of some of these missions i helped

1300
00:49:34,790 --> 00:49:33,119
out with some of the early the lunar

1301
00:49:36,710 --> 00:49:34,800
prospector mission

1302
00:49:38,790 --> 00:49:36,720
and you know trying to be in the right

1303
00:49:41,990 --> 00:49:38,800
place at the right time and as you said

1304
00:49:44,630 --> 00:49:42,000
determination i would say perseverance

1305
00:49:46,069 --> 00:49:44,640
there's a lot of steps where it doesn't

1306
00:49:47,430 --> 00:49:46,079
go right and you just keep pushing

1307
00:49:50,230 --> 00:49:47,440
forward and

1308
00:49:54,390 --> 00:49:50,240
um you know good things often happen so

1309
00:49:56,790 --> 00:49:54,400
that's the advice keep keep persevering

1310
00:49:59,270 --> 00:49:56,800
well i got my degree in mathematics

1311
00:50:03,190 --> 00:49:59,280
undergraduate degree and mathematics

1312
00:50:08,230 --> 00:50:05,750
i benefited greatly from the

1313
00:50:10,790 --> 00:50:08,240

cold war and the competition and the

1314
00:50:12,870 --> 00:50:10,800
emphasis on science

1315
00:50:15,829 --> 00:50:12,880
technology and mathematics education

1316
00:50:18,390 --> 00:50:15,839
that resulted uh which i'm hoping that

1317
00:50:19,510 --> 00:50:18,400
others will benefit from in the future

1318
00:50:22,790 --> 00:50:19,520
uh

1319
00:50:26,630 --> 00:50:22,800
after a few detours i became as did sean

1320
00:50:28,230 --> 00:50:26,640
an earth scientist looking at the bottom

1321
00:50:31,750 --> 00:50:28,240
of the oceans

1322
00:50:34,710 --> 00:50:31,760
of the earth i did my phd degree on

1323
00:50:37,190 --> 00:50:34,720
marine geophysics using sonar and

1324
00:50:40,390 --> 00:50:37,200
gravity and other geophysical techniques

1325
00:50:44,230 --> 00:50:40,400
magnetometry to understand the motion of

1326
00:50:45,430 --> 00:50:44,240
the earth's crust and how it forms

1327
00:50:47,030 --> 00:50:45,440
i guess with

1328
00:50:51,430 --> 00:50:47,040
the

1329
00:50:53,190 --> 00:50:51,440
and mars global surveyor missions

1330
00:50:55,670 --> 00:50:53,200
providing me the opportunity to use

1331
00:50:58,230 --> 00:50:55,680
lasers instead of sonar i became a

1332
00:51:00,630 --> 00:50:58,240
planetary scientist

1333
00:51:02,309 --> 00:51:00,640
but it was very hard to resist the

1334
00:51:03,990 --> 00:51:02,319
thrill of being able to make the first

1335
00:51:07,349 --> 00:51:04,000
observations of

1336
00:51:09,589 --> 00:51:07,359
a body outside of the earth with lasers

1337
00:51:10,790 --> 00:51:09,599
and make maps and

1338
00:51:12,790 --> 00:51:10,800

the rest

1339
00:51:15,109 --> 00:51:12,800
has kind of fallen into place until now

1340
00:51:18,549 --> 00:51:15,119
it's full circle we're measuring water

1341
00:51:22,950 --> 00:51:21,430
thanks my association with nasa started

1342
00:51:25,349 --> 00:51:22,960
very early

1343
00:51:28,470 --> 00:51:25,359
i was selected as part of a national

1344
00:51:31,750 --> 00:51:28,480
competition to fly a student experiment

1345
00:51:34,870 --> 00:51:31,760
on the convair 990 which was a jet

1346
00:51:37,670 --> 00:51:34,880
aircraft that was run by nasa ames

1347
00:51:39,829 --> 00:51:37,680
and uh i designed an experiment and then

1348
00:51:42,549 --> 00:51:39,839
got to fly to nasa ames and got to fly

1349
00:51:44,230 --> 00:51:42,559
on this conveyor 990 around the north

1350
00:51:47,190 --> 00:51:44,240
polar region of the earth as it turns

1351
00:51:49,270 --> 00:51:47,200
out we went to alaska and to greenland

1352
00:51:51,829 --> 00:51:49,280
it even flew over the north pole and

1353
00:51:54,630 --> 00:51:51,839
this aircraft flew at about a thousand

1354
00:51:56,069 --> 00:51:54,640
feet the entire time elevation with all

1355
00:51:57,430 --> 00:51:56,079
kinds of remote sensing instruments

1356
00:52:00,950 --> 00:51:57,440
getting radar

1357
00:52:02,309 --> 00:52:00,960
uh getting laser altimetry and every

1358
00:52:03,990 --> 00:52:02,319
type of remote sensing instrument you

1359
00:52:05,589 --> 00:52:04,000
can get and

1360
00:52:07,190 --> 00:52:05,599
for me to be able to you know hang out

1361
00:52:09,829 --> 00:52:07,200
with the scientists to experience this

1362
00:52:11,670 --> 00:52:09,839
as a high school student was easily the

1363
00:52:13,829 --> 00:52:11,680

most exciting experience i've ever had

1364
00:52:17,030 --> 00:52:13,839
my life both before or after

1365
00:52:18,710 --> 00:52:17,040
and here i am uh you know looking at the

1366
00:52:20,790 --> 00:52:18,720
ice on mercury i wouldn't have thought

1367
00:52:24,470 --> 00:52:20,800
it at the time but i guess i've never

1368
00:52:26,390 --> 00:52:24,480
stopped so i'm really grateful to the uh

1369
00:52:27,270 --> 00:52:26,400
you know opportunity that was provided

1370
00:52:30,950 --> 00:52:27,280
by

1371
00:52:32,710 --> 00:52:30,960
was the name of the guy who

1372
00:52:35,750 --> 00:52:32,720
ran the educational program there but

1373
00:52:39,030 --> 00:52:36,870
okay what we're going to do is we're

1374
00:52:40,549 --> 00:52:39,040
going to we're going to end here again

1375
00:52:42,870 --> 00:52:40,559
for the folks who

1376
00:52:45,190 --> 00:52:42,880
are on twitter and google plus and

1377
00:52:47,190 --> 00:52:45,200
facebook the conversation does not stop

1378
00:52:49,750 --> 00:52:47,200
here join the conversation particularly

1379
00:52:51,510 --> 00:52:49,760
on twitter at hashtag ask

1380
00:52:53,589 --> 00:52:51,520
nasa we'll continue to answer your

1381
00:52:55,270 --> 00:52:53,599
questions and for the media who on the

1382
00:52:57,430 --> 00:52:55,280
phone line are watching this

1383
00:52:59,589 --> 00:52:57,440
the individuals will be available for

1384
00:53:02,710 --> 00:52:59,599
interviews following this contact myself

1385
00:53:03,990 --> 00:53:02,720
or my colleague paulette campbell apl

1386
00:53:06,309 --> 00:53:04,000
again i want to congratulate the

1387
00:53:08,069 --> 00:53:06,319
messenger team you can get the

1388
00:53:09,829 --> 00:53:08,079

information and the latest

1389
00:53:13,670 --> 00:53:09,839
images and other

1390
00:53:16,390 --> 00:53:13,680
science information on www.nasa.gov