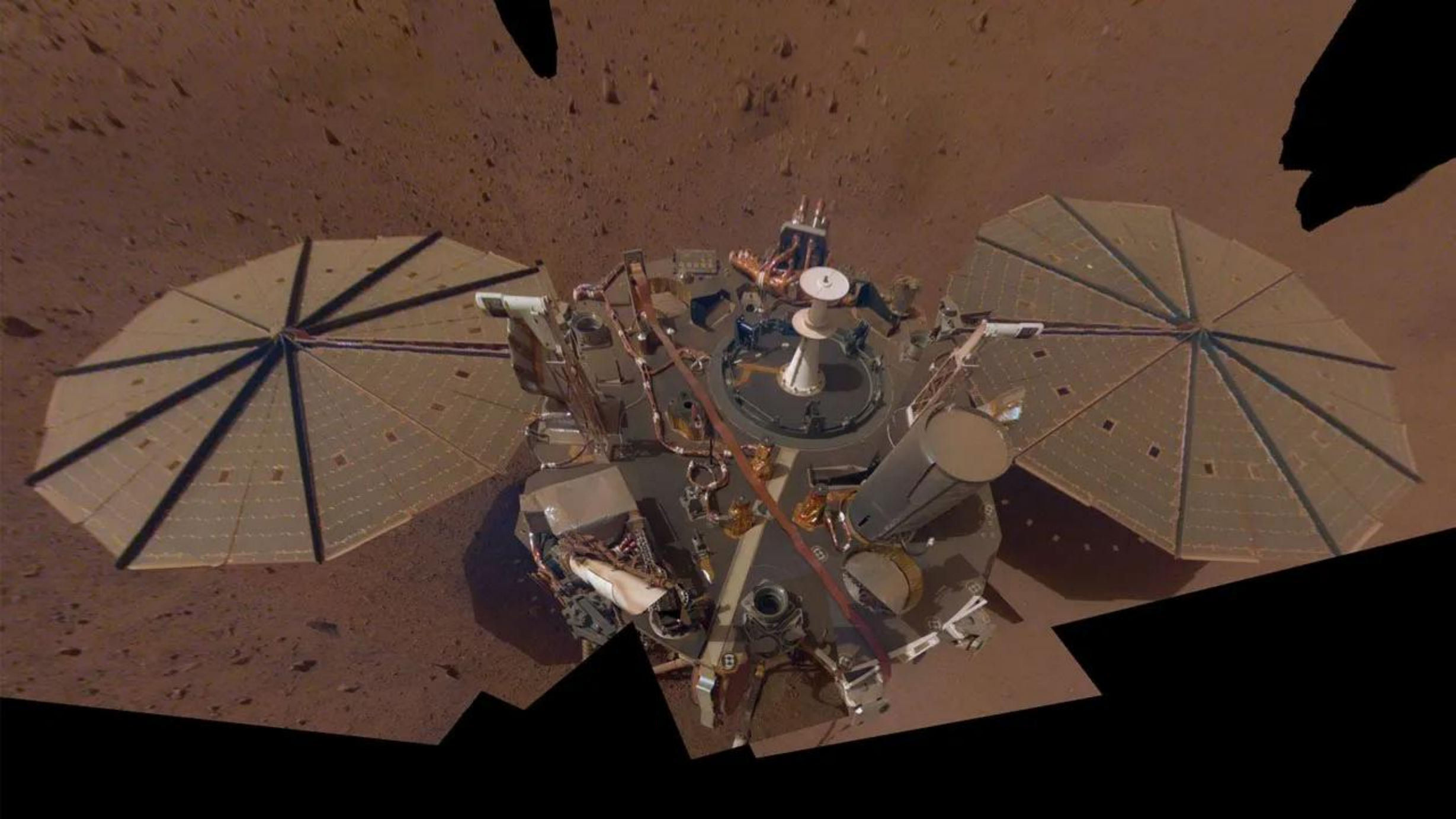

1
00:00:05,870 --> 00:00:04,070
good evening folks my name is Mark

2
00:00:08,450 --> 00:00:05,880
Razzie from jpl's Office of

3
00:00:10,490 --> 00:00:08,460
communications and education and it is

4
00:00:12,290 --> 00:00:10,500
my absolute pleasure to be your host for

5
00:00:14,390 --> 00:00:12,300
this evening's edition of the Von Carmen

6
00:00:16,129 --> 00:00:14,400
lecture series before we get started

7
00:00:18,769 --> 00:00:16,139
though let me please welcome in our

8
00:00:21,890 --> 00:00:18,779
co-host this evening Sarah Marcotte from

9
00:00:25,189 --> 00:00:21,900
the Mars public engagement team hi Sarah

10
00:00:27,650 --> 00:00:25,199
hello hello uh Sarah Marcotte here

11
00:00:30,950 --> 00:00:27,660
public engagement specialist from the

12
00:00:33,110 --> 00:00:30,960
Mars exploration program so near the end

13
00:00:36,110 --> 00:00:33,120

of our show tonight I will be Fielding

14
00:00:38,090 --> 00:00:36,120
your questions from LinkedIn YouTube and

15
00:00:40,729 --> 00:00:38,100
Facebook now if you're on one of those

16
00:00:43,910 --> 00:00:40,739
platforms and you don't see a check box

17
00:00:46,430 --> 00:00:43,920
there try refreshing your browser and it

18
00:00:49,369 --> 00:00:46,440
should pop up now since you have joined

19
00:00:51,830 --> 00:00:49,379
us tonight and you are interested in the

20
00:00:54,410 --> 00:00:51,840
Insight missions insights about Mars

21
00:00:56,510 --> 00:00:54,420
after tonight's program you might also

22
00:00:59,330 --> 00:00:56,520
want to check out the science highlights

23
00:01:01,250 --> 00:00:59,340
page on the mission website so I'm

24
00:01:03,590 --> 00:01:01,260
really looking forward to tonight's

25
00:01:06,350 --> 00:01:03,600
conversation so I will turn it back to

26
00:01:10,609 --> 00:01:08,990
uh thank you very much Sarah so our

27
00:01:12,350 --> 00:01:10,619
topic tonight as Sarah so kindly

28
00:01:14,750 --> 00:01:12,360
mentioned is in fact the Insight Mission

29
00:01:16,730 --> 00:01:14,760
to Mars now this Mission planned yet

30
00:01:18,410 --> 00:01:16,740
another risky Landing attempt on Mars

31
00:01:20,630 --> 00:01:18,420
and sought to reveal

32
00:01:23,330 --> 00:01:20,640
the interior structure of the red planet

33
00:01:27,170 --> 00:01:23,340
having accomplished that Landing in

34
00:01:29,090 --> 00:01:27,180
November 26 on November 26th of 2018 the

35
00:01:31,310 --> 00:01:29,100
mission went on to more than double its

36
00:01:34,249 --> 00:01:31,320
life span and finally ended in December

37
00:01:35,929 --> 00:01:34,259
of 2022. so to tell us more about the

38
00:01:38,749 --> 00:01:35,939

spacecraft and its accomplishments we

39
00:01:41,030 --> 00:01:38,759
have two fantastic guests tonight jpl's

40
00:01:43,609 --> 00:01:41,040
very own Dr Mark panning who is the

41
00:01:46,130 --> 00:01:43,619
Insight Mission Project scientist and Dr

42
00:01:47,990 --> 00:01:46,140
Ingrid dalbar an assistant professor of

43
00:01:49,789 --> 00:01:48,000
research at Brown University at an

44
00:01:51,830 --> 00:01:49,799
Insight Mission participating scientist

45
00:01:53,210 --> 00:01:51,840
so to start it off to start us off

46
00:01:55,429 --> 00:01:53,220
rather this evening let's first welcome

47
00:01:58,149 --> 00:01:55,439
in Dr panning so hey Mark how you doing

48
00:02:01,069 --> 00:01:58,159
my friend thanks for joining us tonight

49
00:02:03,530 --> 00:02:01,079
hi uh yeah it's uh it's really great to

50
00:02:07,130 --> 00:02:03,540
be here I'm excited to talk about uh the

51
00:02:10,969 --> 00:02:09,410
or we're grateful for your participation

52
00:02:13,309 --> 00:02:10,979
tonight seriously

53
00:02:14,750 --> 00:02:13,319
um so first to start us all off um let's

54
00:02:18,229 --> 00:02:14,760
talk about the mission goals what kind

55
00:02:22,070 --> 00:02:18,239
of information was uh was Insight after

56
00:02:23,510 --> 00:02:22,080
yeah so um so there's a Insight is an

57
00:02:25,309 --> 00:02:23,520
interesting Mars mission in a lot of

58
00:02:26,390 --> 00:02:25,319
ways so there's been a lot of missions

59
00:02:27,949 --> 00:02:26,400
to Mars

60
00:02:29,570 --> 00:02:27,959
um and most of them have been mainly

61
00:02:31,729 --> 00:02:29,580
focused on looking at things on the

62
00:02:34,070 --> 00:02:31,739
surface or in the atmosphere and there's

63
00:02:36,110 --> 00:02:34,080

lots of exciting stuff to look at there

64
00:02:38,510 --> 00:02:36,120
um but uh insights was the first mission

65
00:02:40,610 --> 00:02:38,520
that really the whole point was to try

66
00:02:41,930 --> 00:02:40,620
to look at the interior and try to

67
00:02:44,330 --> 00:02:41,940
understand what was happening deep

68
00:02:46,910 --> 00:02:44,340
inside and to use that to basically

69
00:02:49,729 --> 00:02:46,920
understand a whole lot more about how

70
00:02:51,850 --> 00:02:49,739
rocky planets uh our form and evolve so

71
00:02:55,070 --> 00:02:51,860
that would include Earth

72
00:02:56,990 --> 00:02:55,080
and Venus and Mercury and Mars and and

73
00:02:59,449 --> 00:02:57,000
pretty much the Moon too it's not

74
00:03:01,430 --> 00:02:59,459
technically a planet but um I I will uh

75
00:03:03,410 --> 00:03:01,440
freely admit that I I am loose in my

76
00:03:05,990 --> 00:03:03,420
definition of planet I don't necessarily

77
00:03:09,650 --> 00:03:06,000
agree with the iau on that

78
00:03:11,930 --> 00:03:09,660
um so um if we bring up uh image one

79
00:03:13,490 --> 00:03:11,940
I think it's a probably a a good way of

80
00:03:16,250 --> 00:03:13,500
uh describing what what I'm talking

81
00:03:17,990 --> 00:03:16,260
about so when you Google what's the

82
00:03:19,610 --> 00:03:18,000
inside the planet look like or or

83
00:03:21,229 --> 00:03:19,620
something like that you get all of these

84
00:03:23,030 --> 00:03:21,239
cross-sections

85
00:03:24,890 --> 00:03:23,040
um you know cut planets cut in half and

86
00:03:28,070 --> 00:03:24,900
you see all the circles that are are the

87
00:03:31,430 --> 00:03:28,080
layers the core the mantle the crust

88
00:03:33,350 --> 00:03:31,440

um and the kind of dirty secret is

89
00:03:35,990 --> 00:03:33,360
for most of these we're kind of guessing

90
00:03:37,550 --> 00:03:36,000
we know things about the gravity

91
00:03:39,890 --> 00:03:37,560
um and that can give you some some

92
00:03:41,750 --> 00:03:39,900
guesses on the general makeup of things

93
00:03:43,490 --> 00:03:41,760
the general layers but a lot of the

94
00:03:45,949 --> 00:03:43,500
details are missing so you can see um

95
00:03:49,430 --> 00:03:45,959
this is a an older image from 2014

96
00:03:50,869 --> 00:03:49,440
showing all these cutaway pictures

97
00:03:52,610 --> 00:03:50,879
um and the Earth and the moon are

98
00:03:55,309 --> 00:03:52,620
actually pretty well known

99
00:03:57,649 --> 00:03:55,319
because we've done seismology on them

100
00:03:59,330 --> 00:03:57,659
and we know what the insides look like

101
00:04:01,570 --> 00:03:59,340
we have all of these layers pretty well

102
00:04:05,089 --> 00:04:01,580
known but at the time of this figure

103
00:04:06,830 --> 00:04:05,099
really all of those uh those numbers on

104
00:04:08,270 --> 00:04:06,840
Mars were question marks we just didn't

105
00:04:10,970 --> 00:04:08,280
really know they were basically just

106
00:04:13,190 --> 00:04:10,980
guesses and um in order to you know

107
00:04:16,189 --> 00:04:13,200
really understand the interior we

108
00:04:18,289 --> 00:04:16,199
decided uh to send a mission that was

109
00:04:21,110 --> 00:04:18,299
focused on doing measurements that were

110
00:04:24,770 --> 00:04:21,120
sensitive to the inside of Mars so if

111
00:04:31,010 --> 00:04:28,189
that's got a lot of the instruments that

112
00:04:34,070 --> 00:04:31,020
uh that we decided to to fly

113
00:04:37,249 --> 00:04:34,080

um and these are the three main uh sets

114
00:04:39,050 --> 00:04:37,259
of instruments so there's uh the uh the

115
00:04:41,030 --> 00:04:39,060
one that's out front

116
00:04:42,590 --> 00:04:41,040
um uh looks like a kind of upside down

117
00:04:44,510 --> 00:04:42,600
pie plate on top of it that's the

118
00:04:46,249 --> 00:04:44,520
seismometer

119
00:04:47,570 --> 00:04:46,259
um I'm a seismologist so that's my

120
00:04:49,310 --> 00:04:47,580
favorite instrument but they're all

121
00:04:51,590 --> 00:04:49,320
really important

122
00:04:54,110 --> 00:04:51,600
um and then uh the other two prime

123
00:04:55,610 --> 00:04:54,120
instruments we had were the HP cubed

124
00:04:57,530 --> 00:04:55,620
which stands for heat flow and physical

125
00:05:00,770 --> 00:04:57,540
properties probe

126
00:05:03,230 --> 00:05:00,780
um and uh it uh was designed to go down

127
00:05:05,990 --> 00:05:03,240
in the ground about uh three to five

128
00:05:08,749 --> 00:05:06,000
meters which is up to about 15 feet

129
00:05:10,370 --> 00:05:08,759
um uh and uh it didn't make it that far

130
00:05:12,110 --> 00:05:10,380
but its goal was to be able to measure

131
00:05:14,749 --> 00:05:12,120
heat flow instead it managed to measure

132
00:05:17,570 --> 00:05:14,759
some of the the physical properties of

133
00:05:19,370 --> 00:05:17,580
the subsurface near near insight and

134
00:05:22,730 --> 00:05:19,380
finally the last uh major instrument

135
00:05:24,529 --> 00:05:22,740
Prime instrument was uh the rise uh

136
00:05:27,170 --> 00:05:24,539
Mission which

137
00:05:29,810 --> 00:05:27,180
um basically was radio science uh it was

138
00:05:30,950 --> 00:05:29,820

using uh transmitters that talk directly

139
00:05:33,469 --> 00:05:30,960
to Earth

140
00:05:36,350 --> 00:05:33,479
and it used those in order to look at

141
00:05:38,270 --> 00:05:36,360
very small wobbles of the of the planet

142
00:05:40,430 --> 00:05:38,280
as it was rotating so it's kind of you

143
00:05:42,469 --> 00:05:40,440
could tell what the inside of a milk jug

144
00:05:47,870 --> 00:05:42,479
is when you wiggle it the rise

145
00:05:51,230 --> 00:05:49,550
um but it turns out all of these

146
00:05:53,629 --> 00:05:51,240
instruments are really sensitive oh go

147
00:05:56,810 --> 00:05:55,010
yeah no I was gonna say that's a pretty

148
00:05:58,070 --> 00:05:56,820
that's a pretty cool instrument package

149
00:06:00,050 --> 00:05:58,080
and as you were going to talk about we

150
00:06:01,430 --> 00:06:00,060
talked about this in our in our

151
00:06:04,189 --> 00:06:01,440
discussions beforehand yeah we always

152
00:06:06,529 --> 00:06:04,199
tell folks you know space is hard and I

153
00:06:09,170 --> 00:06:06,539
remember hearing the story about when

154
00:06:11,150 --> 00:06:09,180
they were testing the seismometer I

155
00:06:14,029 --> 00:06:11,160
think was in Denver that they were able

156
00:06:17,390 --> 00:06:14,039
to measure or actually detect like ocean

157
00:06:19,189 --> 00:06:17,400
waves crashing on the Pacific coast so

158
00:06:21,350 --> 00:06:19,199
like how do you how do you guys like

159
00:06:23,090 --> 00:06:21,360
manage that that challenge and I'm sure

160
00:06:25,370 --> 00:06:23,100
that was just one of many

161
00:06:26,990 --> 00:06:25,380
yeah so so seismometers are really

162
00:06:29,110 --> 00:06:27,000
sensitive instruments um it turns out if

163
00:06:31,370 --> 00:06:29,120

you put a seismometer anywhere on Earth

164
00:06:33,469 --> 00:06:31,380
you'll always hear the oceans it doesn't

165
00:06:34,610 --> 00:06:33,479
matter where you are you can always hear

166
00:06:36,529 --> 00:06:34,620
the oceans if you've got a good enough

167
00:06:38,270 --> 00:06:36,539
seismometer they're they're always

168
00:06:40,010 --> 00:06:38,280
making noise on Earth

169
00:06:41,330 --> 00:06:40,020
um and so

170
00:06:42,110 --> 00:06:41,340
um yeah these are very sensitive

171
00:06:44,029 --> 00:06:42,120
instruments and they're actually

172
00:06:46,330 --> 00:06:44,039
sensitive to lots of things not just the

173
00:06:49,370 --> 00:06:46,340
ground motion um it turns out when

174
00:06:52,010 --> 00:06:49,380
Magnetic storms come through they move

175
00:06:54,230 --> 00:06:52,020
the instrument uh when uh pressure and

176
00:06:56,809 --> 00:06:54,240
wind all of these things affect it so we

177
00:06:59,390 --> 00:06:56,819
have a a secondary science payload so

178
00:07:01,070 --> 00:06:59,400
that's uh image three

179
00:07:02,809 --> 00:07:01,080
and I'm not going to go through all of

180
00:07:04,370 --> 00:07:02,819
these but this is basically a whole

181
00:07:05,809 --> 00:07:04,380
bunch of other instruments that are out

182
00:07:06,890 --> 00:07:05,819
there to measure all of the things that

183
00:07:09,110 --> 00:07:06,900
can complicate the measurement

184
00:07:11,629 --> 00:07:09,120
particularly for the seismometer

185
00:07:13,969 --> 00:07:11,639
um so we've got wind sensors we've got

186
00:07:16,189 --> 00:07:13,979
pressure sensors got cameras

187
00:07:18,350 --> 00:07:16,199
magnetometer

188
00:07:19,670 --> 00:07:18,360

all of these things

189
00:07:21,469 --> 00:07:19,680
um actually have been able to do great

190
00:07:23,689 --> 00:07:21,479
science on their own

191
00:07:25,850 --> 00:07:23,699
um but the the justification for

192
00:07:27,710 --> 00:07:25,860
including them was that we wanted to to

193
00:07:29,210 --> 00:07:27,720
make sure that we're knowing all the

194
00:07:30,409 --> 00:07:29,220
things that can mess up the seismic

195
00:07:32,089 --> 00:07:30,419
signals

196
00:07:33,710 --> 00:07:32,099
um but you know what I was talking about

197
00:07:37,129 --> 00:07:33,720
about the oceans is actually really

198
00:07:39,409 --> 00:07:37,139
fascinating thing to think about because

199
00:07:40,969 --> 00:07:39,419
um on earth when you're trying to get a

200
00:07:42,650 --> 00:07:40,979
really really quiet seismic station you

201
00:07:46,129 --> 00:07:42,660
do all sorts of crazy things you put it

202
00:07:48,230 --> 00:07:46,139
deep down in mind uh or or or drill down

203
00:07:51,050 --> 00:07:48,240
uh hundreds of meters into the ground

204
00:07:53,629 --> 00:07:51,060
and try to get them really really quiet

205
00:07:55,610 --> 00:07:53,639
um on Insight we flew and had an arm

206
00:07:58,249 --> 00:07:55,620
that put it out there

207
00:07:59,749 --> 00:07:58,259
um on a tripod on top of a big pile of

208
00:08:01,490 --> 00:07:59,759
dirt effectively

209
00:08:03,050 --> 00:08:01,500
um which on Earth that would make a

210
00:08:05,510 --> 00:08:03,060
really noisy station but because there's

211
00:08:07,430 --> 00:08:05,520
no oceans on Mars our station is about

212
00:08:10,610 --> 00:08:07,440
two orders of magnitude quieter than any

213
00:08:13,249 --> 00:08:10,620

station on Earth so uh we installed the

214
00:08:16,990 --> 00:08:13,259
best seismic station in the solar system

215
00:08:21,890 --> 00:08:20,150
that's that's pretty impressive so I

216
00:08:23,990 --> 00:08:21,900
guess once all it was all was said and

217
00:08:26,570 --> 00:08:24,000
done what were your kind of impressions

218
00:08:28,010 --> 00:08:26,580
of the mission how did it do

219
00:08:30,770 --> 00:08:28,020
um we we

220
00:08:33,769 --> 00:08:30,780
um did everything we promised basically

221
00:08:35,990 --> 00:08:33,779
uh we were very very very happy with our

222
00:08:40,070 --> 00:08:36,000
uh uh results on looking at the interior

223
00:08:43,370 --> 00:08:40,080
so um if you bring up uh slide four

224
00:08:45,350 --> 00:08:43,380
um I I find this one fascinating

225
00:08:47,630 --> 00:08:45,360
because this is

226
00:08:49,670 --> 00:08:47,640
um basically all of the seismic data of

227
00:08:51,650 --> 00:08:49,680
the entire mission in one picture and I

228
00:08:53,329 --> 00:08:51,660
think that's that that's kind of uh

229
00:08:56,269 --> 00:08:53,339
impressive to figure out but basically

230
00:08:57,949 --> 00:08:56,279
each line going across here is one soul

231
00:08:59,150 --> 00:08:57,959
on Mars and the soul on Mars is what we

232
00:09:00,530 --> 00:08:59,160
call a day

233
00:09:02,449 --> 00:09:00,540
um there it's a little bit longer than

234
00:09:03,949 --> 00:09:02,459
an earth day but uh but pretty close to

235
00:09:07,850 --> 00:09:03,959
the length of an Earth Day

236
00:09:09,230 --> 00:09:07,860
and um the the colors on each row if

237
00:09:10,490 --> 00:09:09,240
it's a purpley color it means it's

238
00:09:13,370 --> 00:09:10,500

really quiet there's not a lot of

239
00:09:14,930 --> 00:09:13,380
seismic background noise and if it's an

240
00:09:16,130 --> 00:09:14,940
orange yellowy color it means it's

241
00:09:17,630 --> 00:09:16,140
pretty noisy

242
00:09:19,430 --> 00:09:17,640
um and you can see the pattern every day

243
00:09:23,269 --> 00:09:19,440
that it's it's noisier in the middle of

244
00:09:24,769 --> 00:09:23,279
the day and and and quieter at night and

245
00:09:26,810 --> 00:09:24,779
um you can see there's also all of these

246
00:09:29,870 --> 00:09:26,820
little colored dots on there actually

247
00:09:31,910 --> 00:09:29,880
that's 1300 Mars Quakes

248
00:09:33,230 --> 00:09:31,920
um uh we had a huge number that we were

249
00:09:34,730 --> 00:09:33,240
able to record

250
00:09:35,870 --> 00:09:34,740
um and they you could see they happen in

251
00:09:37,790 --> 00:09:35,880
the purple times because that's when

252
00:09:39,410 --> 00:09:37,800
it's really quiet on on Mars and so we

253
00:09:41,389 --> 00:09:39,420
can see these events most of which are

254
00:09:42,850 --> 00:09:41,399
pretty pretty tiny

255
00:09:45,050 --> 00:09:42,860
um a few of them are are are are

256
00:09:47,030 --> 00:09:45,060
relatively big you can see there's

257
00:09:49,370 --> 00:09:47,040
labeled there on the kind of lower left

258
00:09:51,410 --> 00:09:49,380
there's one that's a magnitude 4.7

259
00:09:53,030 --> 00:09:51,420
that's big for Mars it's the biggest one

260
00:09:55,130 --> 00:09:53,040
we ever recorded um if you live in

261
00:09:56,329 --> 00:09:55,140
California like I do 4.7 doesn't sound

262
00:09:58,250 --> 00:09:56,339
giant

263
00:10:00,290 --> 00:09:58,260

um uh but it but for Mars that's a

264
00:10:03,170 --> 00:10:00,300
that's a really giant event

265
00:10:04,009 --> 00:10:03,180
um and uh uh so with all of these Mars

266
00:10:07,009 --> 00:10:04,019
quakes

267
00:10:08,690 --> 00:10:07,019
we are able to look for signals that

268
00:10:10,370 --> 00:10:08,700
interacted with all those layers I

269
00:10:12,290 --> 00:10:10,380
showed earlier so we were able to see

270
00:10:15,590 --> 00:10:12,300
seismic waves that did things like

271
00:10:17,570 --> 00:10:15,600
bounce off the core of Mars or that uh

272
00:10:20,090 --> 00:10:17,580
uh interacted with the crust below the

273
00:10:23,389 --> 00:10:20,100
station and by using all of that data we

274
00:10:25,490 --> 00:10:23,399
were able to put a lot of uh numbers on

275
00:10:26,930 --> 00:10:25,500
all of those cross sections

276
00:10:28,790 --> 00:10:26,940
um and and we learned some really

277
00:10:32,150 --> 00:10:28,800
interesting things for example the core

278
00:10:34,310 --> 00:10:32,160
of Mars is right at the biggest end of

279
00:10:35,930 --> 00:10:34,320
what we expected before the mission

280
00:10:38,329 --> 00:10:35,940
um it's also liquid we found that out

281
00:10:39,650 --> 00:10:38,339
that was expected but we confirmed it

282
00:10:41,810 --> 00:10:39,660
with the data

283
00:10:44,269 --> 00:10:41,820
um and uh by the the fact that it's big

284
00:10:45,590 --> 00:10:44,279
also means it's not very dense which

285
00:10:47,329 --> 00:10:45,600
means that there's all sorts of other

286
00:10:48,710 --> 00:10:47,339
elements in there so there's a lot of

287
00:10:52,069 --> 00:10:48,720
really exciting things and we're very

288
00:10:53,030 --> 00:10:52,079

happy with um the all of the things we

289
00:10:56,090 --> 00:10:53,040
found

290
00:10:59,269 --> 00:10:56,100
um one of the parts we were um a little

291
00:11:00,470 --> 00:10:59,279
uh um concerned about though is that at

292
00:11:01,610 --> 00:11:00,480
the end of the first two years of

293
00:11:03,410 --> 00:11:01,620
mission which was the Prime mission

294
00:11:05,449 --> 00:11:03,420
length we'd recorded a lot of these Mars

295
00:11:07,850 --> 00:11:05,459
Quakes it's about halfway down that that

296
00:11:09,650 --> 00:11:07,860
that figure there is where the the Prime

297
00:11:12,050 --> 00:11:09,660
mission ended you could see there's the

298
00:11:14,090 --> 00:11:12,060
the white dashed line there we've not

299
00:11:15,710 --> 00:11:14,100
seen a lot of Mars Quakes and we've done

300
00:11:18,170 --> 00:11:15,720
a lot of the results we wanted to get

301
00:11:22,970 --> 00:11:18,180
and we were pretty happy about it

302
00:11:28,850 --> 00:11:27,170
um this is a map of all the the Quakes

303
00:11:30,290 --> 00:11:28,860
um uh that we found and they're it's

304
00:11:31,790 --> 00:11:30,300
kind of a funny looking map because all

305
00:11:35,449 --> 00:11:31,800
the Quakes are marked with these kind of

306
00:11:37,910 --> 00:11:35,459
weird uh black circle ellipse things

307
00:11:40,610 --> 00:11:37,920
um and uh but that's how uncertain we

308
00:11:42,350 --> 00:11:40,620
are about the locations it shows a a lot

309
00:11:44,990 --> 00:11:42,360
a lot of different things but the the

310
00:11:46,430 --> 00:11:45,000
this that's how well we can locate it

311
00:11:48,530 --> 00:11:46,440
because we're just with one station and

312
00:11:50,990 --> 00:11:48,540
so it's a difficult process but we're

313
00:11:52,550 --> 00:11:51,000

able to locate all of these events

314
00:11:55,009 --> 00:11:52,560
um but at the end of the mission we

315
00:11:56,870 --> 00:11:55,019
weren't sure we'd seen any impacts and

316
00:11:58,910 --> 00:11:56,880
that was one of our goals we wanted to

317
00:12:01,970 --> 00:11:58,920
see not just Mars Quakes we all wanted

318
00:12:05,690 --> 00:12:01,980
to see impacts from from space

319
00:12:09,050 --> 00:12:05,700
um and uh um it it turns out

320
00:12:10,430 --> 00:12:09,060
um uh Mars was waiting to give us things

321
00:12:12,230 --> 00:12:10,440
um we we got through the Prime mission

322
00:12:14,329 --> 00:12:12,240
and we we didn't see anything that we

323
00:12:16,550 --> 00:12:14,339
were convinced of but there were the the

324
00:12:19,009 --> 00:12:16,560
good stuff was coming and there's some

325
00:12:20,930 --> 00:12:19,019
colored symbols on there um that uh our

326
00:12:22,790 --> 00:12:20,940
next speaker is going to talk about in a

327
00:12:24,170 --> 00:12:22,800
lot more detail but now we is one thing

328
00:12:26,389 --> 00:12:24,180
we were worried about at the end of the

329
00:12:28,610 --> 00:12:26,399
Prime mission but uh Mars really helped

330
00:12:31,850 --> 00:12:28,620
us out when we extended for another full

331
00:12:36,170 --> 00:12:31,860
Mars year which is about two Earth years

332
00:12:40,790 --> 00:12:38,389
nice that's that's cool that's a really

333
00:12:42,769 --> 00:12:40,800
like vast data set so

334
00:12:46,610 --> 00:12:42,779
um let's dive into that then so to do

335
00:12:48,650 --> 00:12:46,620
that I'd like to bring back in Dr dalbar

336
00:12:50,150 --> 00:12:48,660
um who I mentioned before is an uh

337
00:12:52,190 --> 00:12:50,160
participating scientist on The Insight

338
00:12:53,509 --> 00:12:52,200

Mission Ingrid thank you so much for

339
00:12:54,710 --> 00:12:53,519
joining us tonight folks I want you to

340
00:12:56,569 --> 00:12:54,720
realize she's joining us from the East

341
00:12:59,269 --> 00:12:56,579
Coast so it's a little late

342
00:13:01,970 --> 00:12:59,279
but we're grateful for you uh you did

343
00:13:03,290 --> 00:13:01,980
for playing with us tonight so first

344
00:13:07,129 --> 00:13:03,300
let's talk about the kind of data you

345
00:13:09,350 --> 00:13:07,139
were like expecting to find okay yeah so

346
00:13:11,750 --> 00:13:09,360
um if we bring up the next image

347
00:13:13,670 --> 00:13:11,760
um this is an artist rendition of what

348
00:13:16,069 --> 00:13:13,680
we thought we would see with Insight

349
00:13:18,470 --> 00:13:16,079
before Insight landed on Mars we thought

350
00:13:20,030 --> 00:13:18,480
we would see kind of a steady stream of

351
00:13:22,670 --> 00:13:20,040
impacts

352
00:13:25,069 --> 00:13:22,680
um and this is when a meteoroid a piece

353
00:13:26,629 --> 00:13:25,079
of a comet or an asteroid hurdles

354
00:13:30,290 --> 00:13:26,639
through the Martian atmosphere and hits

355
00:13:32,269 --> 00:13:30,300
the surface creates a crater and the

356
00:13:34,910 --> 00:13:32,279
seismometer pictured here would be able

357
00:13:36,710 --> 00:13:34,920
to kind of sense that ground shaking

358
00:13:39,710 --> 00:13:36,720
um and and one thing that impacts have

359
00:13:41,870 --> 00:13:39,720
going for them that regular Quakes don't

360
00:13:42,889 --> 00:13:41,880
um is that we we can tell exactly where

361
00:13:45,949 --> 00:13:42,899
they happened

362
00:13:48,710 --> 00:13:45,959
um so we saw in Mark's map where they

363
00:13:50,990 --> 00:13:48,720

had these these funny loopy circles

364
00:13:53,329 --> 00:13:51,000
um but if an impact happened we could

365
00:13:55,090 --> 00:13:53,339
try to image it from orbit and then we

366
00:13:57,350 --> 00:13:55,100
would know exactly where it happened

367
00:13:59,750 --> 00:13:57,360
unfortunately for like the first three

368
00:14:01,730 --> 00:13:59,760
years on Mars um all we had was this

369
00:14:04,550 --> 00:14:01,740
artist rendition and we didn't find

370
00:14:06,370 --> 00:14:04,560
anything that we thought was an impact

371
00:14:09,110 --> 00:14:06,380
oh no

372
00:14:10,610 --> 00:14:09,120
three years that's a that's a while for

373
00:14:12,829 --> 00:14:10,620
it to be that quiet

374
00:14:14,750 --> 00:14:12,839
um did it so that the daily finally

375
00:14:17,389 --> 00:14:14,760
start rolling in at some point I guess

376
00:14:19,790 --> 00:14:17,399
after that yes yeah so we finally

377
00:14:23,810 --> 00:14:19,800
detected the first impact seismically

378
00:14:25,930 --> 00:14:23,820
and I think if we go to the next image

379
00:14:28,370 --> 00:14:25,940
um this is a seismograph a seismograph

380
00:14:31,310 --> 00:14:28,380
instead of the kind of normal Wiggles

381
00:14:34,250 --> 00:14:31,320
that you might see this shows the power

382
00:14:36,470 --> 00:14:34,260
in different frequencies over time

383
00:14:38,210 --> 00:14:36,480
um so this was the one event that we

384
00:14:46,750 --> 00:14:38,220
finally recognized as an impact after

385
00:14:51,650 --> 00:14:50,389
oh looks like we might have lost Ingrid

386
00:14:54,350 --> 00:14:51,660
there for a moment

387
00:14:55,430 --> 00:14:54,360
so yeah this chart as we had this

388
00:14:57,230 --> 00:14:55,440

discussion a little bit earlier this

389
00:14:59,990 --> 00:14:57,240
shows you some of the acoustic waves

390
00:15:02,509 --> 00:15:00,000
that the spacecraft recorded

391
00:15:04,670 --> 00:15:02,519
um as it impacted the surface I think

392
00:15:06,470 --> 00:15:04,680
the next slide will actually show us

393
00:15:09,290 --> 00:15:06,480
you'll be able to hear what this thing's

394
00:15:23,569 --> 00:15:09,300
what this sounded like

395
00:15:29,449 --> 00:15:26,449
yeah so I'm glad you're listening to

396
00:15:31,610 --> 00:15:29,459
that well I dropped off there

397
00:15:36,009 --> 00:15:31,620
um I love that sound

398
00:15:36,019 --> 00:15:41,689
I love it

399
00:15:44,509 --> 00:15:43,129
yes I just talked to Teeny bit about it

400
00:15:46,910 --> 00:15:44,519
just to fill in if you want to talk a

401
00:15:48,350 --> 00:15:46,920
little more to it feel free yeah so this

402
00:15:51,050 --> 00:15:48,360
is this is if you take that seismograph

403
00:15:52,790 --> 00:15:51,060
and you translate it to frequencies that

404
00:15:54,050 --> 00:15:52,800
the human ear can hear this is what it

405
00:15:56,990 --> 00:15:54,060
sounds like

406
00:15:58,550 --> 00:15:57,000
um to to have an impact on Mars so we

407
00:16:12,889 --> 00:15:58,560
were we were super excited when we

408
00:16:12,899 --> 00:16:17,329
so if you go to the next image

409
00:16:22,550 --> 00:16:18,889
um we actually found a couple of these

410
00:16:23,930 --> 00:16:22,560
so this is a map that shows um three of

411
00:16:27,410 --> 00:16:23,940
these impacts that occurred right near

412
00:16:30,650 --> 00:16:27,420
the Insight Lander and because we're

413
00:16:34,009 --> 00:16:30,660

once we got these bloops um these uh

414
00:16:35,930 --> 00:16:34,019
these chirps in the seismic data

415
00:16:38,150 --> 00:16:35,940
um we could we could get an estimate of

416
00:16:39,530 --> 00:16:38,160
the location of the impact and then we

417
00:16:41,569 --> 00:16:39,540
could ask our friends over in the Mars

418
00:16:44,090 --> 00:16:41,579
reconnaissance Orbiter to take an image

419
00:16:47,150 --> 00:16:44,100
with the orbiting cameras

420
00:16:48,370 --> 00:16:47,160
um so these are context image images and

421
00:16:52,009 --> 00:16:48,380
high-rise images

422
00:16:54,530 --> 00:16:52,019
and it shows a before and after it shows

423
00:16:57,530 --> 00:16:54,540
the new crater has formed at the same

424
00:16:59,269 --> 00:16:57,540
time as we got that seismic data and

425
00:17:03,230 --> 00:16:59,279
then we have a couple close-ups of these

426
00:17:08,510 --> 00:17:06,110
yeah so these are just really gorgeous

427
00:17:10,490 --> 00:17:08,520
um high resolution images from the

428
00:17:14,210 --> 00:17:10,500
high-rise camera

429
00:17:19,370 --> 00:17:17,210
these are enhanced false color so the

430
00:17:20,750 --> 00:17:19,380
the kind of blast zone around the

431
00:17:22,970 --> 00:17:20,760
craters much bigger than the crater

432
00:17:25,610 --> 00:17:22,980
itself and it shows where the dust has

433
00:17:27,470 --> 00:17:25,620
been disturbed by that impact

434
00:17:28,909 --> 00:17:27,480
um and these craters are really tiny

435
00:17:30,350 --> 00:17:28,919
actually in terms of

436
00:17:32,630 --> 00:17:30,360
um

437
00:17:34,070 --> 00:17:32,640
the rest of Mars the rest of the craters

438
00:17:37,010 --> 00:17:34,080

on Mars these are only a few meters

439
00:17:37,669 --> 00:17:37,020
across maybe 10 meters at most

440
00:17:39,590 --> 00:17:37,679
um

441
00:17:41,150 --> 00:17:39,600
so but even though they were tiny they

442
00:17:43,190 --> 00:17:41,160
were Mighty and they were nice and

443
00:17:50,690 --> 00:17:43,200
nearby in sight so they give us some

444
00:17:55,789 --> 00:17:53,930
so I know we wanted to go back and visit

445
00:17:58,250 --> 00:17:55,799
one of the images

446
00:18:01,430 --> 00:17:58,260
which one was it if it was it 12 or is

447
00:18:07,430 --> 00:18:05,150
yeah so yep again oh there you are

448
00:18:09,350 --> 00:18:07,440
image 12.

449
00:18:11,090 --> 00:18:09,360
hopefully I'm still here

450
00:18:13,610 --> 00:18:11,100
um it was Trump so this is the big one

451
00:18:15,529 --> 00:18:13,620
this is the really exciting one

452
00:18:16,970 --> 00:18:15,539
um after we had found those small ones

453
00:18:19,070 --> 00:18:16,980
in your Insight we thought that was

454
00:18:22,010 --> 00:18:19,080
super exciting and then this happened so

455
00:18:24,529 --> 00:18:22,020
this happened on Christmas Eve of 2021

456
00:18:26,090 --> 00:18:24,539
and it's the biggest crater we've ever

457
00:18:27,890 --> 00:18:26,100
seen form

458
00:18:30,529 --> 00:18:27,900
um so this is zoomed way out this is a

459
00:18:32,270 --> 00:18:30,539
context camera image from orbit this

460
00:18:35,570 --> 00:18:32,280
whole Blast Zone around the impact is

461
00:18:40,909 --> 00:18:35,580
about 30 kilometers across and

462
00:18:44,390 --> 00:18:40,919
um we can zoom in with a video 14.

463
00:18:46,669 --> 00:18:44,400

and this is a a movie made from a

464
00:18:48,830 --> 00:18:46,679
three-dimensional image from the

465
00:18:50,570 --> 00:18:48,840
high-rise camera and what we're doing is

466
00:18:52,010 --> 00:18:50,580
we're flying over this crater that

467
00:18:53,990 --> 00:18:52,020
formed so

468
00:18:56,630 --> 00:18:54,000
um this is a it's a huge crater in terms

469
00:18:59,750 --> 00:18:56,640
of current cratering it's about 500 feet

470
00:19:00,950 --> 00:18:59,760
across or about a city block across and

471
00:19:03,590 --> 00:19:00,960
you can see there's these white

472
00:19:06,950 --> 00:19:03,600
splotches all around it this crater

473
00:19:10,070 --> 00:19:06,960
actually coincidentally happened at um

474
00:19:12,650 --> 00:19:10,080
35 degrees north latitude right at the

475
00:19:15,110 --> 00:19:12,660
edge of where water ice is stable in the

476
00:19:17,690 --> 00:19:15,120
shallow subsurface so when this crater

477
00:19:19,669 --> 00:19:17,700
formed and excavated these chunks of ice

478
00:19:23,510 --> 00:19:19,679
you can see splashes of ice out in the

479
00:19:25,310 --> 00:19:23,520
ejecta and some actual chunks of ice

480
00:19:28,490 --> 00:19:25,320
that were thrown out when it when it

481
00:19:30,890 --> 00:19:28,500
occurred so this uh this particular

482
00:19:33,169 --> 00:19:30,900
impact was super exciting these things

483
00:19:35,390 --> 00:19:33,179
we would expect this size crater to

484
00:19:38,029 --> 00:19:35,400
happen only maybe once a generation once

485
00:19:40,669 --> 00:19:38,039
every 20 or 30 years so the fact that it

486
00:19:43,370 --> 00:19:40,679
happened while Insight was listening was

487
00:19:44,450 --> 00:19:43,380
just a huge coincidence and very

488
00:19:46,909 --> 00:19:44,460

fortuitous

489
00:19:49,490 --> 00:19:46,919
so because it happened on Christmas Eve

490
00:19:55,669 --> 00:19:49,500
this really was a spectacular gift for

491
00:20:00,770 --> 00:19:58,310
and super cool love that that video is

492
00:20:03,169 --> 00:20:00,780
great so

493
00:20:05,570 --> 00:20:03,179
even though the mission has kind of

494
00:20:07,310 --> 00:20:05,580
officially ended right

495
00:20:09,890 --> 00:20:07,320
um I have to imagine there's still a ton

496
00:20:12,770 --> 00:20:09,900
of data that you are still continuing to

497
00:20:19,970 --> 00:20:15,770
yeah yeah so we um if you go back to the

498
00:20:22,190 --> 00:20:19,980
the map that Mark showed uh image five

499
00:20:25,549 --> 00:20:22,200
so that shows just some of the Quakes

500
00:20:27,770 --> 00:20:25,559
that um that are those among those 1300

501
00:20:29,210 --> 00:20:27,780
Quakes and now that we have these

502
00:20:32,210 --> 00:20:29,220
impacts that we've just learned about in

503
00:20:34,190 --> 00:20:32,220
the last year or so we have a lot more

504
00:20:39,470 --> 00:20:34,200
still to do so people are going to be

505
00:20:45,110 --> 00:20:42,110
very very cool

506
00:20:46,970 --> 00:20:45,120
all right so given that I think it's

507
00:20:48,350 --> 00:20:46,980
probably a fair time to start checking

508
00:20:51,049 --> 00:20:48,360
in to see what kind of questions we

509
00:20:53,510 --> 00:20:51,059
might have so Sarah if you're out there

510
00:20:56,450 --> 00:20:53,520
how's it looking out there in the in the

511
00:20:58,730 --> 00:20:56,460
social world in the social world so the

512
00:21:01,610 --> 00:20:58,740
questions are coming in and they are

513
00:21:03,529 --> 00:21:01,620

they are very interesting questions so I

514
00:21:06,710 --> 00:21:03,539
can dive in to a couple of them right

515
00:21:08,630 --> 00:21:06,720
now so allow me to read on my screen so

516
00:21:11,029 --> 00:21:08,640
I thought this is a nice sort of

517
00:21:14,390 --> 00:21:11,039
overarching question so this is from Dan

518
00:21:17,090 --> 00:21:14,400
on YouTube Dan asks so what is causing

519
00:21:19,970 --> 00:21:17,100
the Quakes there's no tectonic activity

520
00:21:22,730 --> 00:21:19,980
is there is it cooling of the crust

521
00:21:24,409 --> 00:21:22,740
yeah that's that's a really really good

522
00:21:27,830 --> 00:21:24,419
question and one we thought about a lot

523
00:21:30,049 --> 00:21:27,840
going in so um there are tectonics on

524
00:21:32,930 --> 00:21:30,059
Mars but there are not plate tectonics

525
00:21:35,690 --> 00:21:32,940
on Mars so if you took a a intro geology

526
00:21:37,010 --> 00:21:35,700
course somewhere in your career uh you

527
00:21:39,890 --> 00:21:37,020
you probably learned about plate

528
00:21:42,289 --> 00:21:39,900
tectonics which is what governs most of

529
00:21:44,090 --> 00:21:42,299
the earthquakes and volcanoes on Earth

530
00:21:45,950 --> 00:21:44,100
um the the Earth is divided up in these

531
00:21:48,049 --> 00:21:45,960
plates and they rub against each other

532
00:21:49,370 --> 00:21:48,059
and that's where Quakes happen Mars

533
00:21:50,870 --> 00:21:49,380
doesn't show any evidence of plate

534
00:21:51,950 --> 00:21:50,880
tectonics

535
00:21:54,590 --> 00:21:51,960
um but

536
00:21:56,630 --> 00:21:54,600
um on Earth we actually do see Quakes in

537
00:21:58,730 --> 00:21:56,640
between those plates as well

538
00:22:01,490 --> 00:21:58,740

um the stress is build up and you see

539
00:22:03,710 --> 00:22:01,500
Quakes happen uh on Mars

540
00:22:07,549 --> 00:22:03,720
um there's probably lots of different

541
00:22:09,950 --> 00:22:07,559
things causing it um going in we thought

542
00:22:11,930 --> 00:22:09,960
um overall that the planet Cooling and

543
00:22:14,210 --> 00:22:11,940
Contracting would be the driving force

544
00:22:16,970 --> 00:22:14,220
of most of the Quakes we saw

545
00:22:18,950 --> 00:22:16,980
um now we're not sure exactly whether

546
00:22:22,190 --> 00:22:18,960
that's the driving energy for most of

547
00:22:25,549 --> 00:22:22,200
them or not um uh it turns out uh if you

548
00:22:28,490 --> 00:22:25,559
look at that uh that map number five uh

549
00:22:31,610 --> 00:22:28,500
that there's a this whole big clump of

550
00:22:34,070 --> 00:22:31,620
uh of circles there uh to the to the

551
00:22:35,990 --> 00:22:34,080
east of insight there's a whole bunch

552
00:22:37,549 --> 00:22:36,000
one up right there that's an area called

553
00:22:39,230 --> 00:22:37,559
Cerberus Fosse

554
00:22:41,210 --> 00:22:39,240
and it's actually

555
00:22:43,490 --> 00:22:41,220
um an area that shows the the youngest

556
00:22:45,649 --> 00:22:43,500
volcanism on the surface of Mars there's

557
00:22:47,870 --> 00:22:45,659
eruptions within the last

558
00:22:49,370 --> 00:22:47,880
10 million years now that sounds like a

559
00:22:52,610 --> 00:22:49,380
long time but geologically speaking

560
00:22:55,970 --> 00:22:52,620
trust me that's young and uh um and uh

561
00:22:57,470 --> 00:22:55,980
and so it seems like actually a lot of

562
00:23:00,350 --> 00:22:57,480
the events we're seeing are are related

563
00:23:01,850 --> 00:23:00,360

to ongoing volcanic activity uh at least

564
00:23:03,409 --> 00:23:01,860
in this location

565
00:23:05,510 --> 00:23:03,419
um there's probably lots of other things

566
00:23:07,610 --> 00:23:05,520
that can drive uh Mars Quakes as well

567
00:23:09,830 --> 00:23:07,620
just gravitational settling of these big

568
00:23:11,690 --> 00:23:09,840
loads there are giant volcanoes on Mars

569
00:23:13,610 --> 00:23:11,700
Olympus Mons is Giant and it's sitting

570
00:23:15,529 --> 00:23:13,620
on top of the tharsus Bulge which is

571
00:23:17,090 --> 00:23:15,539
even bigger it's a big weight sitting on

572
00:23:19,490 --> 00:23:17,100
top of the planet you get gravitational

573
00:23:20,870 --> 00:23:19,500
stresses because of that there's likely

574
00:23:23,390 --> 00:23:20,880
other things that we haven't thought of

575
00:23:25,789 --> 00:23:23,400
yet but uh um there are things that

576
00:23:28,970 --> 00:23:25,799
cause stresses which can cause Quakes

577
00:23:31,010 --> 00:23:28,980
even if there isn't plate tectonics to

578
00:23:33,770 --> 00:23:31,020
drive the level of earthquakes that we

579
00:23:37,250 --> 00:23:35,570
okay so I have kind of a related

580
00:23:39,289 --> 00:23:37,260
question to that

581
00:23:41,450 --> 00:23:39,299
um so I'll stay with you Mark and then

582
00:23:43,310 --> 00:23:41,460
Ingrid I have a really good juicy I

583
00:23:46,190 --> 00:23:43,320
can't decide between two for you next

584
00:23:48,649 --> 00:23:46,200
okay so um Bruce on YouTube asks is

585
00:23:52,390 --> 00:23:48,659
there a minimum size of a planetary body

586
00:23:54,529 --> 00:23:52,400
for plate tectonics to take place

587
00:23:57,049 --> 00:23:54,539
I don't know if there's a minimum size

588
00:23:59,510 --> 00:23:57,059

there's whether plate tectonics happens

589
00:24:01,310 --> 00:23:59,520
or not is one of the things that drives

590
00:24:03,950 --> 00:24:01,320
why we want to do

591
00:24:05,270 --> 00:24:03,960
um uh planetary seismology planetary

592
00:24:07,789 --> 00:24:05,280
science in general

593
00:24:09,470 --> 00:24:07,799
um if it were just size that that drove

594
00:24:10,970 --> 00:24:09,480
plate tectonics we would expect to see

595
00:24:13,549 --> 00:24:10,980
evidence of a lot of plate tectonics on

596
00:24:15,049 --> 00:24:13,559
fetus Venus is almost exactly the same

597
00:24:18,110 --> 00:24:15,059
size as Earth

598
00:24:19,610 --> 00:24:18,120
um uh and uh and yet it shows no

599
00:24:22,549 --> 00:24:19,620
evidence of anything like plate

600
00:24:25,669 --> 00:24:22,559
tectonics so there's um obviously a a

601
00:24:28,669 --> 00:24:25,679
multiple set of ingredients that go into

602
00:24:30,890 --> 00:24:28,679
to whether we get plate tectonics or not

603
00:24:33,049 --> 00:24:30,900
and I'm not going to give you a glib I

604
00:24:34,789 --> 00:24:33,059
know the answer answer here because I

605
00:24:36,649 --> 00:24:34,799
don't know the answer

606
00:24:39,289 --> 00:24:36,659
um people think it may have to do with

607
00:24:40,850 --> 00:24:39,299
presence or absence of water in the

608
00:24:43,070 --> 00:24:40,860
Earth's mantle

609
00:24:45,649 --> 00:24:43,080
um uh there are lots of people who have

610
00:24:47,390 --> 00:24:45,659
lots of theories but um this is this is

611
00:24:49,250 --> 00:24:47,400
why we study other planets actually this

612
00:24:50,630 --> 00:24:49,260
is something always came up before the

613
00:24:52,390 --> 00:24:50,640

mission people are like well why are you

614
00:24:54,590 --> 00:24:52,400
gonna you know

615
00:24:56,029 --> 00:24:54,600
on Mars that's a lot of effort it's a

616
00:24:57,890 --> 00:24:56,039
long way away

617
00:24:59,149 --> 00:24:57,900
um you know and um I say we want to

618
00:25:00,590 --> 00:24:59,159
study these other planets because it's

619
00:25:03,649 --> 00:25:00,600
like you don't become a really good

620
00:25:05,390 --> 00:25:03,659
doctor by only working on one patient so

621
00:25:07,010 --> 00:25:05,400
if you want to understand the planets

622
00:25:09,590 --> 00:25:07,020
you've got to work on multiple patients

623
00:25:10,850 --> 00:25:09,600
here and so um this is uh one thing

624
00:25:13,730 --> 00:25:10,860
we're looking at and trying to

625
00:25:19,070 --> 00:25:17,029
okay thank you so a lot of impact

626
00:25:20,270 --> 00:25:19,080
questions are coming in Ingrid so we

627
00:25:22,669 --> 00:25:20,280
might keep you here till you know

628
00:25:24,409 --> 00:25:22,679
midnight but I'll just pick and choose

629
00:25:26,269 --> 00:25:24,419
some of the good ones

630
00:25:28,010 --> 00:25:26,279
um they're all good I love all my

631
00:25:31,070 --> 00:25:28,020
children but there's some very

632
00:25:32,269 --> 00:25:31,080
interesting questions here so um where

633
00:25:34,250 --> 00:25:32,279
was it

634
00:25:36,350 --> 00:25:34,260
I've already lost it there it goes Manny

635
00:25:38,570 --> 00:25:36,360
on LinkedIn is asking are any of the

636
00:25:41,990 --> 00:25:38,580
impact sites being investigated for new

637
00:25:45,830 --> 00:25:43,549
um so I'm not sure exactly what new

638
00:25:48,289 --> 00:25:45,840

material elements might mean but the the

639
00:25:50,750 --> 00:25:48,299
one that we showed the video of

640
00:25:53,690 --> 00:25:50,760
um it does have exposed water ice which

641
00:25:55,549 --> 00:25:53,700
is uh really exciting to see because

642
00:25:57,830 --> 00:25:55,559
it's the closest to the equator we've

643
00:25:59,870 --> 00:25:57,840
ever seen water ice so that's telling us

644
00:26:01,850 --> 00:25:59,880
a lot about kind of the climate history

645
00:26:05,269 --> 00:26:01,860
of Mars and when the water would have

646
00:26:07,370 --> 00:26:05,279
been stable there and also what what

647
00:26:09,890 --> 00:26:07,380
resources might be close to the surface

648
00:26:11,990 --> 00:26:09,900
for future exploration

649
00:26:14,810 --> 00:26:12,000
neat well then you answer the question

650
00:26:17,029 --> 00:26:14,820
from Ankit on Facebook because Ankit was

651
00:26:19,310 --> 00:26:17,039
wondering if the Creator's data analysis

652
00:26:22,490 --> 00:26:19,320
was showing any signs of water so it

653
00:26:23,110 --> 00:26:22,500
sounds like water ice is evident in at

654
00:26:25,909 --> 00:26:23,120
least

655
00:26:28,850 --> 00:26:25,919
those bright blotches that you saw in

656
00:26:31,190 --> 00:26:28,860
the video that's all Water Ice

657
00:26:34,190 --> 00:26:31,200
neat okay so I have to have another

658
00:26:37,070 --> 00:26:34,200
impact question so uh lily flower on

659
00:26:39,169 --> 00:26:37,080
YouTube is asking so how small are the

660
00:26:41,269 --> 00:26:39,179
rocks that cause all the craters and how

661
00:26:43,610 --> 00:26:41,279
fast are they going when they hit

662
00:26:45,649 --> 00:26:43,620
oh that's a really good question so we

663
00:26:47,149 --> 00:26:45,659

are able to make some educated guesses

664
00:26:48,830 --> 00:26:47,159
about that

665
00:26:51,470 --> 00:26:48,840
um usually they're about 10 times

666
00:26:53,570 --> 00:26:51,480
smaller than the crater itself so for

667
00:26:56,750 --> 00:26:53,580
those 150 meter crater it was probably

668
00:26:58,669 --> 00:26:56,760
you know 15 meters in diameter

669
00:27:00,710 --> 00:26:58,679
um roughly

670
00:27:02,149 --> 00:27:00,720
um of course the the impactor is

671
00:27:04,490 --> 00:27:02,159
completely destroyed so we don't

672
00:27:06,830 --> 00:27:04,500
actually have any any evidence of it but

673
00:27:08,750 --> 00:27:06,840
we can we can do that based on modeling

674
00:27:11,390 --> 00:27:08,760
and how and what we know about in

675
00:27:12,350 --> 00:27:11,400
macphysics and in terms of how fast

676
00:27:14,510 --> 00:27:12,360
they're going

677
00:27:16,970 --> 00:27:14,520
um most things hitting Mars are going

678
00:27:19,190 --> 00:27:16,980
about 10 kilometers per second but the

679
00:27:20,830 --> 00:27:19,200
atmosphere there is even though Mars has

680
00:27:22,970 --> 00:27:20,840
a very thin atmosphere it's still

681
00:27:25,370 --> 00:27:22,980
substantial it's enough to slow down

682
00:27:26,870 --> 00:27:25,380
these impactors so we think the really

683
00:27:28,789 --> 00:27:26,880
small ones like those really small

684
00:27:31,010 --> 00:27:28,799
craters that I showed

685
00:27:32,390 --> 00:27:31,020
um they those impactors get slowed down

686
00:27:34,789 --> 00:27:32,400
to something more like a couple

687
00:27:36,470 --> 00:27:34,799
kilometers per second but that's still

688
00:27:41,690 --> 00:27:36,480

really really fast fast enough to cause

689
00:27:47,149 --> 00:27:45,289
okay this one is for you mark so um and

690
00:27:48,289 --> 00:27:47,159
you alluded to this a little bit earlier

691
00:27:51,289 --> 00:27:48,299
so

692
00:27:54,590 --> 00:27:51,299
um CM on LinkedIn is asking will the

693
00:27:57,169 --> 00:27:54,600
data be publicly available too

694
00:27:59,149 --> 00:27:57,179
um so the seismic data not only will be

695
00:28:01,250 --> 00:27:59,159
publicly available it is already

696
00:28:03,230 --> 00:28:01,260
publicly available

697
00:28:04,490 --> 00:28:03,240
um we have we were we basically

698
00:28:06,950 --> 00:28:04,500
throughout the course of the mission

699
00:28:10,430 --> 00:28:06,960
released a chunk of data every three

700
00:28:11,690 --> 00:28:10,440
months um this was one of the selling

701
00:28:13,370 --> 00:28:11,700
points of the mission from the beginning

702
00:28:15,710 --> 00:28:13,380
is that we wanted to be very open and

703
00:28:17,930 --> 00:28:15,720
let all seismologists who wanted to look

704
00:28:19,789 --> 00:28:17,940
at the seismic data do it um people who

705
00:28:21,350 --> 00:28:19,799
wanted to get access to the weather data

706
00:28:23,630 --> 00:28:21,360
the weather data came out even faster

707
00:28:26,210 --> 00:28:23,640
that was out on the web basically as

708
00:28:28,669 --> 00:28:26,220
soon as we as it came down you could go

709
00:28:31,130 --> 00:28:28,679
and look at what the weather was like at

710
00:28:34,549 --> 00:28:31,140
the Insight The Landing site of any time

711
00:28:36,110 --> 00:28:34,559
you wanted but the uh entire all of the

712
00:28:37,310 --> 00:28:36,120
seismic data from the mission is

713
00:28:38,990 --> 00:28:37,320

available

714
00:28:40,909 --> 00:28:39,000
um it's through multiple websites if

715
00:28:43,070 --> 00:28:40,919
you're a seismologist you may know about

716
00:28:45,169 --> 00:28:43,080
Iris which is the Incorporated research

717
00:28:47,029 --> 00:28:45,179
institutions of seismology you can

718
00:28:48,710 --> 00:28:47,039
download our data there just like you

719
00:28:49,850 --> 00:28:48,720
would download any other station on

720
00:28:52,250 --> 00:28:49,860
Earth

721
00:28:55,549 --> 00:28:52,260
um uh it's just on Mars

722
00:28:57,590 --> 00:28:55,559
um so uh that that data available and

723
00:28:59,090 --> 00:28:57,600
you know we love to see other people

724
00:29:02,450 --> 00:28:59,100
work on the data

725
00:29:04,070 --> 00:29:02,460
um I I have high expectations that

726
00:29:05,990 --> 00:29:04,080
people will be working on this data for

727
00:29:09,590 --> 00:29:06,000
a long time to come

728
00:29:12,590 --> 00:29:09,600
um the only other extensive uh data set

729
00:29:15,289 --> 00:29:12,600
of planetary seismology and once again

730
00:29:18,950 --> 00:29:15,299
I'm being loose on planet but the Apollo

731
00:29:22,190 --> 00:29:18,960
Landings all included seismometers and

732
00:29:24,409 --> 00:29:22,200
four of those uh Landing sites had uh

733
00:29:28,070 --> 00:29:24,419
seismic stations that lasted a long time

734
00:29:30,350 --> 00:29:28,080
but they actually got turned off in 1977

735
00:29:32,210 --> 00:29:30,360
two months after I was born and people

736
00:29:35,810 --> 00:29:32,220
are still publishing

737
00:29:37,430 --> 00:29:35,820
um and while I'm still only 21.

738
00:29:40,190 --> 00:29:37,440

um uh maybe that was a little bit longer

739
00:29:42,049 --> 00:29:40,200
than that ago people are still people

740
00:29:44,690 --> 00:29:42,059
are still publishing with that data so

741
00:29:48,409 --> 00:29:44,700
I'm uh expecting that

742
00:29:50,570 --> 00:29:48,419
um some of the newborns today

743
00:29:52,850 --> 00:29:50,580
um are are going to be publishing about

744
00:29:57,110 --> 00:29:52,860
Insight seismology when they're um

745
00:30:02,810 --> 00:30:00,049
great okay I have um probably for you

746
00:30:04,789 --> 00:30:02,820
mark as well um these are two

747
00:30:06,649 --> 00:30:04,799
two questions from YouTube but they're

748
00:30:09,230 --> 00:30:06,659
kind of related and there's so much

749
00:30:11,510 --> 00:30:09,240
enthusiasm out here so

750
00:30:14,149 --> 00:30:11,520
um Tim on YouTube is oh I hope we see

751
00:30:17,330 --> 00:30:14,159
more seismometers on Mars so what's next

752
00:30:20,090 --> 00:30:17,340
any plans and then riddle on YouTube

753
00:30:23,210 --> 00:30:20,100
also is asking what about Venus can we

754
00:30:24,529 --> 00:30:23,220
put a seismometer on Venus

755
00:30:25,789 --> 00:30:24,539
um these these they're both great

756
00:30:28,430 --> 00:30:25,799
questions

757
00:30:31,310 --> 00:30:28,440
um I will say uh for Mars right now

758
00:30:33,289 --> 00:30:31,320
there are no direct plans there are no

759
00:30:36,490 --> 00:30:33,299
plans specifically in the works to put

760
00:30:38,330 --> 00:30:36,500
another seismometer on Mars um um I am

761
00:30:40,250 --> 00:30:38,340
optimistic that there will be more

762
00:30:42,710 --> 00:30:40,260
seismometers on Mars in the future but

763
00:30:44,810 --> 00:30:42,720

uh that's that that's subject to uh the

764
00:30:47,029 --> 00:30:44,820
people who hold the purse strings

765
00:30:49,970 --> 00:30:47,039
um but uh for example I would love to

766
00:30:52,070 --> 00:30:49,980
see uh Landing a small network of of

767
00:30:54,230 --> 00:30:52,080
lower sensitivity seismometers but are

768
00:30:55,730 --> 00:30:54,240
landing right on Cerberus Fosse

769
00:30:56,870 --> 00:30:55,740
um you know I think that'd be great I

770
00:30:58,130 --> 00:30:56,880
think we could do some really cool

771
00:31:00,049 --> 00:30:58,140
science there

772
00:31:02,029 --> 00:31:00,059
um but you know we have to be patient

773
00:31:04,310 --> 00:31:02,039
planetary science is really all about

774
00:31:05,510 --> 00:31:04,320
patience missions take a long time to

775
00:31:08,269 --> 00:31:05,520
develop

776
00:31:11,389 --> 00:31:08,279
um uh and so uh we you know we started

777
00:31:15,110 --> 00:31:11,399
uh the process well if you talk to the

778
00:31:17,149 --> 00:31:15,120
principal investigator of of insight

779
00:31:19,190 --> 00:31:17,159
um uh Bruce Banner

780
00:31:21,470 --> 00:31:19,200
um he basically began work on trying to

781
00:31:23,269 --> 00:31:21,480
get seismometers on Mars

782
00:31:24,830 --> 00:31:23,279
um certainly back in the 90s perhaps

783
00:31:27,289 --> 00:31:24,840
back in the 80s

784
00:31:29,269 --> 00:31:27,299
um uh and it's been a long process to

785
00:31:32,450 --> 00:31:29,279
get to the point that we got uh data

786
00:31:34,370 --> 00:31:32,460
from Mars in 2018. so um certain amount

787
00:31:36,529 --> 00:31:34,380
of patience on that um as far as other

788
00:31:37,909 --> 00:31:36,539

planetary bodies um I will say we

789
00:31:39,470 --> 00:31:37,919
already have data from the moon but

790
00:31:40,610 --> 00:31:39,480
there will be more data from the Moon

791
00:31:42,830 --> 00:31:40,620
I'm

792
00:31:44,750 --> 00:31:42,840
personally involved in getting a project

793
00:31:46,850 --> 00:31:44,760
where we're trying to land the

794
00:31:49,070 --> 00:31:46,860
seismometer on the far side of of the

795
00:31:51,649 --> 00:31:49,080
Moon which uh uh is going on a

796
00:31:53,510 --> 00:31:51,659
commercial Lander as far as Venus

797
00:31:55,669 --> 00:31:53,520
um Landing a seismometer on the surface

798
00:31:57,049 --> 00:31:55,679
of Venus um I think it would be great

799
00:31:58,850 --> 00:31:57,059
and I would love to see it but if

800
00:31:59,870 --> 00:31:58,860
there's some really big challenges with

801
00:32:02,210 --> 00:31:59,880
that

802
00:32:05,450 --> 00:32:02,220
um uh you want to have a long-lived uh

803
00:32:07,850 --> 00:32:05,460
uh seismic station on a planet that's

804
00:32:09,830 --> 00:32:07,860
um very very hot very very high pressure

805
00:32:12,590 --> 00:32:09,840
and a very very corrosive atmosphere

806
00:32:14,750 --> 00:32:12,600
that's a that's a challenging Mission

807
00:32:17,090 --> 00:32:14,760
um people are working on developing

808
00:32:18,649 --> 00:32:17,100
electronics and seismometers that may be

809
00:32:21,950 --> 00:32:18,659
able to work in that condition um but I

810
00:32:24,169 --> 00:32:21,960
would imagine what we'll see before then

811
00:32:26,210 --> 00:32:24,179
um and what I hope to see um is to see

812
00:32:27,110 --> 00:32:26,220
uh balloons going in the atmosphere of

813
00:32:28,610 --> 00:32:27,120

Venus

814
00:32:31,070 --> 00:32:28,620
um and you can put pressure sensors on

815
00:32:33,169 --> 00:32:31,080
those and it turns out seismic waves do

816
00:32:35,870 --> 00:32:33,179
couple into the atmosphere on Earth you

817
00:32:37,850 --> 00:32:35,880
can see earthquakes by bouncing signals

818
00:32:39,710 --> 00:32:37,860
off of the ionosphere

819
00:32:41,210 --> 00:32:39,720
um similar things could be done in the

820
00:32:42,769 --> 00:32:41,220
atmosphere of Venus so

821
00:32:44,870 --> 00:32:42,779
um there are people who are working on

822
00:32:48,529 --> 00:32:44,880
that all over the world some people here

823
00:32:52,130 --> 00:32:48,539
at JPL are working on that thinking

824
00:32:54,169 --> 00:32:52,140
about ways of doing seismology on Venus

825
00:32:55,909 --> 00:32:54,179
wow so Mark I see you've put some

826
00:32:57,950 --> 00:32:55,919
thought into this that's good that's

827
00:33:00,590 --> 00:32:57,960
good should always have a future

828
00:33:01,610 --> 00:33:00,600
in your pocket you know just in case you

829
00:33:03,590 --> 00:33:01,620
know you might need someone in an

830
00:33:06,289 --> 00:33:03,600
elevator whatever

831
00:33:08,870 --> 00:33:06,299
um okay Ingrid this question is for you

832
00:33:11,090 --> 00:33:08,880
this is from Henry on YouTube Henry is

833
00:33:13,909 --> 00:33:11,100
asking how do you differentiate the

834
00:33:14,570 --> 00:33:13,919
Quakes caused by the foreign impacts

835
00:33:16,789 --> 00:33:14,580
um

836
00:33:18,409 --> 00:33:16,799
as opposed to the ones created by the

837
00:33:20,990 --> 00:33:18,419
Mars tectonics

838
00:33:23,870 --> 00:33:21,000

yeah that is such a good question and um

839
00:33:26,210 --> 00:33:23,880
before we got to Mars we had all kinds

840
00:33:28,490 --> 00:33:26,220
of ideas on how we might tell the

841
00:33:31,070 --> 00:33:28,500
difference between Quakes and impacts

842
00:33:32,990 --> 00:33:31,080
um most of those were wrong because

843
00:33:34,549 --> 00:33:33,000
that's what happens when you um when you

844
00:33:36,049 --> 00:33:34,559
do exploration

845
00:33:38,690 --> 00:33:36,059
um and and

846
00:33:40,370 --> 00:33:38,700
um those the the bloops that you heard

847
00:33:42,049 --> 00:33:40,380
the little chirps those are the main

848
00:33:43,549 --> 00:33:42,059
things that um that we use to

849
00:33:45,470 --> 00:33:43,559
differentiate

850
00:33:47,269 --> 00:33:45,480
um impacts from

851
00:33:50,330 --> 00:33:47,279
um from kind of

852
00:33:52,250 --> 00:33:50,340
internal tectonic sources

853
00:33:54,230 --> 00:33:52,260
um it also helps when we have an image

854
00:33:55,430 --> 00:33:54,240
of the crater so

855
00:33:57,049 --> 00:33:55,440
um in the case of the Christmas Eve

856
00:33:59,389 --> 00:33:57,059
crater we actually had the image of the

857
00:34:02,090 --> 00:33:59,399
crater first and then they connected it

858
00:34:04,310 --> 00:34:02,100
with the seismic signal

859
00:34:05,750 --> 00:34:04,320
um so so there are um there are

860
00:34:07,909 --> 00:34:05,760
characteristics

861
00:34:10,310 --> 00:34:07,919
um of the of the seismic signals that

862
00:34:12,950 --> 00:34:10,320
can tell us that they are Quakes

863
00:34:14,930 --> 00:34:12,960

um that um yeah that we're learning

864
00:34:18,470 --> 00:34:14,940
because Mars is teaching us new things

865
00:34:23,990 --> 00:34:22,129
okay so Mark may I ask another one I

866
00:34:26,089 --> 00:34:24,000
think we're still going okay

867
00:34:27,889 --> 00:34:26,099
all right so this is from Jared in

868
00:34:29,629 --> 00:34:27,899
YouTube and Ingrid I'm Gonna Keep it

869
00:34:31,369 --> 00:34:29,639
with you here

870
00:34:33,649 --> 00:34:31,379
um did we learn anything about the

871
00:34:36,470 --> 00:34:33,659
frequency of asteroid impacts on Mars

872
00:34:39,050 --> 00:34:36,480
and were there fewer than expected

873
00:34:41,990 --> 00:34:39,060
yeah so that's something I'm trying to

874
00:34:44,930 --> 00:34:42,000
I'm working on actively right now

875
00:34:46,849 --> 00:34:44,940
um there there weren't necessarily fewer

876
00:34:47,570 --> 00:34:46,859
than we expected

877
00:34:49,790 --> 00:34:47,580
um

878
00:34:51,530 --> 00:34:49,800
insight

879
00:34:54,530 --> 00:34:51,540
um can only detect things if they're

880
00:34:56,270 --> 00:34:54,540
really close or really big

881
00:34:58,970 --> 00:34:56,280
um and and you can see that's kind of

882
00:35:01,310 --> 00:34:58,980
the the star the ones that we saw were

883
00:35:03,050 --> 00:35:01,320
the small ones were close by and the big

884
00:35:05,150 --> 00:35:03,060
ones were far away

885
00:35:06,770 --> 00:35:05,160
um so if you look at it kind of um

886
00:35:08,210 --> 00:35:06,780
overall

887
00:35:10,550 --> 00:35:08,220
um it's about the rate that we would

888
00:35:12,650 --> 00:35:10,560

have expected but um but there is kind

889
00:35:13,970 --> 00:35:12,660
of a coincidence in timing where we

890
00:35:15,950 --> 00:35:13,980
didn't see anything for the first three

891
00:35:17,569 --> 00:35:15,960
years and then we saw

892
00:35:19,910 --> 00:35:17,579
um all of them kind of towards the end

893
00:35:21,470 --> 00:35:19,920
of the mission so um it's still kind of

894
00:35:23,690 --> 00:35:21,480
an open question I think

895
00:35:26,510 --> 00:35:23,700
um whether that's just a coincidence or

896
00:35:29,630 --> 00:35:26,520
we just got lucky

897
00:35:32,530 --> 00:35:29,640
um or or whether that's just um Mars

898
00:35:38,450 --> 00:35:34,910
Mars is always having fun with us

899
00:35:40,849 --> 00:35:38,460
apparently Mars observes certain

900
00:35:43,310 --> 00:35:40,859
holidays too

901
00:35:45,470 --> 00:35:43,320
um and sends you know as droids your way

902
00:35:46,550 --> 00:35:45,480
to fit in your Christmas stocking I

903
00:35:49,310 --> 00:35:46,560
guess

904
00:35:50,810 --> 00:35:49,320
um I have another question

905
00:35:53,030 --> 00:35:50,820
um actually I'm gonna throw this one at

906
00:35:54,170 --> 00:35:53,040
you mark not not throw it at you but you

907
00:35:56,450 --> 00:35:54,180
know what I mean

908
00:35:58,910 --> 00:35:56,460
um Chris on LinkedIn is asking

909
00:36:01,310 --> 00:35:58,920
um why were you not able to reach the 15

910
00:36:03,710 --> 00:36:01,320
meter depth Target I assume he's talking

911
00:36:06,470 --> 00:36:03,720
about the HP cubed instruments yes um

912
00:36:09,109 --> 00:36:06,480
and that's that's a really good question

913
00:36:10,730 --> 00:36:09,119

um and and uh so

914
00:36:13,130 --> 00:36:10,740
um the

915
00:36:14,750 --> 00:36:13,140
HP cubed mole which is what we called

916
00:36:15,710 --> 00:36:14,760
the the part that was supposed to go

917
00:36:19,130 --> 00:36:15,720
down

918
00:36:21,890 --> 00:36:19,140
um uh effectively is what we what you

919
00:36:24,050 --> 00:36:21,900
could call a self-driving nail

920
00:36:27,109 --> 00:36:24,060
um it's uh it's uh you know this long

921
00:36:29,329 --> 00:36:27,119
cylindrical uh um thing and it has a

922
00:36:30,770 --> 00:36:29,339
mass in it that uh gets cranked up and

923
00:36:32,390 --> 00:36:30,780
then drops down

924
00:36:33,470 --> 00:36:32,400
um and that that hammers it down a

925
00:36:35,150 --> 00:36:33,480
little bit

926
00:36:36,890 --> 00:36:35,160
um uh and then it just repeats that over

927
00:36:39,410 --> 00:36:36,900
and over again and is designed to go

928
00:36:43,250 --> 00:36:39,420
down and on tests it could go down um in

929
00:36:45,770 --> 00:36:43,260
loose material uh quite quite a distance

930
00:36:48,109 --> 00:36:45,780
um what our leading understanding for

931
00:36:51,950 --> 00:36:48,119
why it wasn't able to penetrate as well

932
00:36:53,870 --> 00:36:51,960
as we had expected is that the the

933
00:36:56,510 --> 00:36:53,880
surface material

934
00:36:58,609 --> 00:36:56,520
um where we landed

935
00:37:02,810 --> 00:36:58,619
um ended up being a little more um

936
00:37:05,750 --> 00:37:02,820
cohesive and stuck together better than

937
00:37:08,150 --> 00:37:05,760
um than we had modeled beforehand and so

938
00:37:10,670 --> 00:37:08,160

with as the as the mole was going down

939
00:37:12,530 --> 00:37:10,680
it actually pushed the material away and

940
00:37:14,750 --> 00:37:12,540
made a pit around the mole and we

941
00:37:17,270 --> 00:37:14,760
actually saw this we picked up the uh

942
00:37:18,650 --> 00:37:17,280
the the the the structure that it would

943
00:37:20,569 --> 00:37:18,660
have been sitting on top of the mole and

944
00:37:21,950 --> 00:37:20,579
moved aside so we could take pictures of

945
00:37:23,990 --> 00:37:21,960
where it was and it opened up a pit

946
00:37:26,390 --> 00:37:24,000
around itself

947
00:37:28,010 --> 00:37:26,400
um and so when that happens the

948
00:37:29,870 --> 00:37:28,020
hammering happens and it goes down a

949
00:37:31,550 --> 00:37:29,880
little bit but there's no ground around

950
00:37:32,750 --> 00:37:31,560
it to resist it just popping right back

951
00:37:34,910 --> 00:37:32,760
up

952
00:37:36,829 --> 00:37:34,920
um uh and so uh it wasn't able to

953
00:37:38,870 --> 00:37:36,839
penetrate in fact

954
00:37:40,250 --> 00:37:38,880
um at one point uh in the process of

955
00:37:42,530 --> 00:37:40,260
trying to get it to go down it actually

956
00:37:44,329 --> 00:37:42,540
backed itself out um actually two points

957
00:37:46,130 --> 00:37:44,339
it backed itself out it was a lot of

958
00:37:49,130 --> 00:37:46,140
stress uh

959
00:37:51,109 --> 00:37:49,140
um it was uh so we did lots of things to

960
00:37:53,569 --> 00:37:51,119
try to counteract this we dug in

961
00:37:54,530 --> 00:37:53,579
material filled in around it and pressed

962
00:37:56,690 --> 00:37:54,540
down

963
00:37:59,810 --> 00:37:56,700

um uh and with a lot of work we were

964
00:38:02,930 --> 00:37:59,820
able to you know rest the the the scoop

965
00:38:05,630 --> 00:38:02,940
on it um and which this was a a really

966
00:38:07,970 --> 00:38:05,640
fun job for all the engineers

967
00:38:10,250 --> 00:38:07,980
um uh coming up with things to use the

968
00:38:11,750 --> 00:38:10,260
scoop for um at some point in the

969
00:38:13,130 --> 00:38:11,760
mission we had considered not including

970
00:38:15,589 --> 00:38:13,140
the scoop because we didn't have plans

971
00:38:17,329 --> 00:38:15,599
for it but we managed to use it for all

972
00:38:18,829 --> 00:38:17,339
sorts of different things but with that

973
00:38:21,349 --> 00:38:18,839
we were able to push it down and we

974
00:38:23,210 --> 00:38:21,359
buried it uh and and pushed down on it

975
00:38:25,310 --> 00:38:23,220
but even with that it still just kept

976
00:38:27,950 --> 00:38:25,320
opening up pits around itself is all we

977
00:38:30,470 --> 00:38:27,960
configure and was just never able to to

978
00:38:32,329 --> 00:38:30,480
get down as far as we wanted to go but

979
00:38:33,890 --> 00:38:32,339
it did get entirely buried and so it was

980
00:38:35,569 --> 00:38:33,900
able to make some measurements of the

981
00:38:38,950 --> 00:38:35,579
the properties of the near surface of

982
00:38:42,170 --> 00:38:38,960
Mars which are very interesting and and

983
00:38:44,150 --> 00:38:42,180
there there are still coming science

984
00:38:47,630 --> 00:38:44,160
papers looking at all of that in more

985
00:38:53,870 --> 00:38:51,470
I like it more more papers more fun

986
00:38:55,849 --> 00:38:53,880
um I have another question from Jared on

987
00:38:58,490 --> 00:38:55,859
YouTube asking

988
00:38:59,990 --> 00:38:58,500

um and I guess I'll stay with you Mark

989
00:39:01,670 --> 00:39:00,000
um how much did the results of the

990
00:39:03,530 --> 00:39:01,680
seismometer the results of the

991
00:39:07,430 --> 00:39:03,540
seismometer compare with the previous

992
00:39:08,690 --> 00:39:07,440
estimates of the Mars interior

993
00:39:11,150 --> 00:39:08,700
yeah

994
00:39:13,430 --> 00:39:11,160
there were there were no things we found

995
00:39:15,890 --> 00:39:13,440
that are our pre-mission expectations

996
00:39:19,010 --> 00:39:15,900
were totally wrong

997
00:39:21,530 --> 00:39:19,020
um uh you know so we but there were

998
00:39:24,109 --> 00:39:21,540
things that you know so we had broad

999
00:39:27,230 --> 00:39:24,119
uncertainty on how big things were so

1000
00:39:30,530 --> 00:39:27,240
example the the the radius of the core

1001
00:39:32,270 --> 00:39:30,540
we uh the the range of estimates of the

1002
00:39:34,250 --> 00:39:32,280
size of Mars core before the mission

1003
00:39:36,530 --> 00:39:34,260
where

1004
00:39:40,790 --> 00:39:36,540
about uh three or four hundred

1005
00:39:42,470 --> 00:39:40,800
kilometers uh and and of variability

1006
00:39:45,829 --> 00:39:42,480
um you could you could come up you could

1007
00:39:48,050 --> 00:39:45,839
either have a really small dense core or

1008
00:39:49,370 --> 00:39:48,060
you could have a really big not very

1009
00:39:50,870 --> 00:39:49,380
dense core

1010
00:39:53,150 --> 00:39:50,880
um and so when we got the data we found

1011
00:39:54,109 --> 00:39:53,160
out it was a very big not very dense

1012
00:39:55,849 --> 00:39:54,119
core

1013
00:39:57,770 --> 00:39:55,859

um and it was right at the upper end of

1014
00:39:59,510 --> 00:39:57,780
that of that limit

1015
00:40:03,710 --> 00:39:59,520
um the the crust

1016
00:40:05,690 --> 00:40:03,720
um uh was uh kind of in the middle of

1017
00:40:07,790 --> 00:40:05,700
the range there had been some some

1018
00:40:10,190 --> 00:40:07,800
papers that had come out that had made

1019
00:40:13,670 --> 00:40:10,200
big splashes that said uh Mars was going

1020
00:40:16,370 --> 00:40:13,680
to have a very thick very dense crust

1021
00:40:18,530 --> 00:40:16,380
um uh uh and uh and as soon as we

1022
00:40:20,030 --> 00:40:18,540
started seeing details on the thickness

1023
00:40:22,790 --> 00:40:20,040
of the crust we knew that we could

1024
00:40:24,589 --> 00:40:22,800
eliminate those models uh the that it

1025
00:40:28,069 --> 00:40:24,599
didn't have that and so

1026
00:40:29,810 --> 00:40:28,079
um it was it was more about going from

1027
00:40:32,390 --> 00:40:29,820
what the pre-measing expectations were

1028
00:40:34,849 --> 00:40:32,400
which had very large uncertainties and

1029
00:40:36,829 --> 00:40:34,859
discovering that those pre-mission

1030
00:40:39,050 --> 00:40:36,839
expectations weren't wrong but now we

1031
00:40:42,290 --> 00:40:39,060
are able to really narrow in and say the

1032
00:40:43,370 --> 00:40:42,300
the real size and start getting at you

1033
00:40:45,770 --> 00:40:43,380
know

1034
00:40:47,150 --> 00:40:45,780
what's in the core for example for it to

1035
00:40:49,310 --> 00:40:47,160
be that light there has to be a lot of

1036
00:40:51,410 --> 00:40:49,320
stuff besides iron and nickel which is

1037
00:40:52,910 --> 00:40:51,420
most of what the core is made out of

1038
00:40:55,310 --> 00:40:52,920

um and so I think there's going to be a

1039
00:40:56,870 --> 00:40:55,320
lot more thinking about uh the

1040
00:40:58,670 --> 00:40:56,880
interpretation of all of that and what

1041
00:41:00,109 --> 00:40:58,680
it means for

1042
00:41:04,930 --> 00:41:00,119
um you know

1043
00:41:07,849 --> 00:41:04,940
why Mars doesn't have a a magnetic field

1044
00:41:10,310 --> 00:41:07,859
an internal magnetic field now it's it's

1045
00:41:11,630 --> 00:41:10,320
uh there are lots of questions that we

1046
00:41:13,730 --> 00:41:11,640
can start addressing now that we

1047
00:41:19,430 --> 00:41:13,740
understand how big the core is and a

1048
00:41:24,349 --> 00:41:21,950
excellent okay thank you thank you Mark

1049
00:41:26,050 --> 00:41:24,359
Sarah let's do one more see if we've got

1050
00:41:28,790 --> 00:41:26,060
anything we can throw to Ingrid's way

1051
00:41:31,430 --> 00:41:28,800
yeah I've got one for Ingrid right here

1052
00:41:34,130 --> 00:41:31,440
I have it right in my pocket this is

1053
00:41:37,069 --> 00:41:34,140
from Dan on YouTube and Dan's gonna

1054
00:41:39,589 --> 00:41:37,079
bring it home Dan asks do the moons

1055
00:41:42,589 --> 00:41:39,599
Phobos and demos have any effect on the

1056
00:41:44,630 --> 00:41:42,599
trajectory of the meteors

1057
00:41:45,650 --> 00:41:44,640
oh that's a that's a really interesting

1058
00:41:47,870 --> 00:41:45,660
idea

1059
00:41:51,109 --> 00:41:47,880
um I think there there would probably be

1060
00:41:53,510 --> 00:41:51,119
too small to really affect them too much

1061
00:41:55,910 --> 00:41:53,520
um their Phobos and demos are are pretty

1062
00:41:58,609 --> 00:41:55,920
small as moons go

1063
00:42:00,050 --> 00:41:58,619

um and the things kind of coming in to

1064
00:42:02,690 --> 00:42:00,060
hit Mars are coming from all directions

1065
00:42:04,370 --> 00:42:02,700
so I suppose once in a while they

1066
00:42:07,190 --> 00:42:04,380
probably do intersect them because we do

1067
00:42:08,870 --> 00:42:07,200
see Craters of Phobos and demos but um

1068
00:42:11,270 --> 00:42:08,880
but in general they don't have enough

1069
00:42:17,089 --> 00:42:11,280
gravity to really mess with everything

1070
00:42:22,069 --> 00:42:20,270
very good well everybody I think we're

1071
00:42:24,349 --> 00:42:22,079
going to wrap it up

1072
00:42:26,210 --> 00:42:24,359
um thank you so much for everything uh

1073
00:42:27,710 --> 00:42:26,220
that's all the time we really do have so

1074
00:42:29,750 --> 00:42:27,720
first of all let me thank Mark and

1075
00:42:31,490 --> 00:42:29,760
Ingrid for all your time and dedication

1076
00:42:33,109 --> 00:42:31,500
to this Mission

1077
00:42:34,670 --> 00:42:33,119
um Sarah thank you so much for handling

1078
00:42:36,109 --> 00:42:34,680
all those questions and all of you folks

1079
00:42:38,690 --> 00:42:36,119
on social media behind the scenes that

1080
00:42:40,490 --> 00:42:38,700
help make that happen our audio visual

1081
00:42:42,530 --> 00:42:40,500
team for making this work of course we

1082
00:42:44,390 --> 00:42:42,540
really appreciate all of you and of

1083
00:42:46,190 --> 00:42:44,400
course everybody watching tonight thank

1084
00:42:48,829 --> 00:42:46,200
you so much you know this is your space

1085
00:42:50,450 --> 00:42:48,839
program after all the least we can do is

1086
00:42:52,069 --> 00:42:50,460
to present these things for you folks to

1087
00:42:53,089 --> 00:42:52,079
kind of keep you up to date and let you

1088
00:42:54,770 --> 00:42:53,099

know what's going on so we really

1089
00:42:57,470 --> 00:42:54,780
appreciate your interest and enthusiasm

1090
00:43:00,470 --> 00:42:57,480
so please join us next month when we'll

1091
00:43:02,630 --> 00:43:00,480
talk about the amazing cryo cooler

1092
00:43:03,890 --> 00:43:02,640
that's on the James Webb Space Telescope

1093
00:43:06,410 --> 00:43:03,900
which is one of the things that really

1094
00:43:07,790 --> 00:43:06,420
helps it really allows it to peer into

1095
00:43:10,190 --> 00:43:07,800
the deepest parts of our universe

1096
00:43:14,030 --> 00:43:10,200
that'll be a really neat talk so until