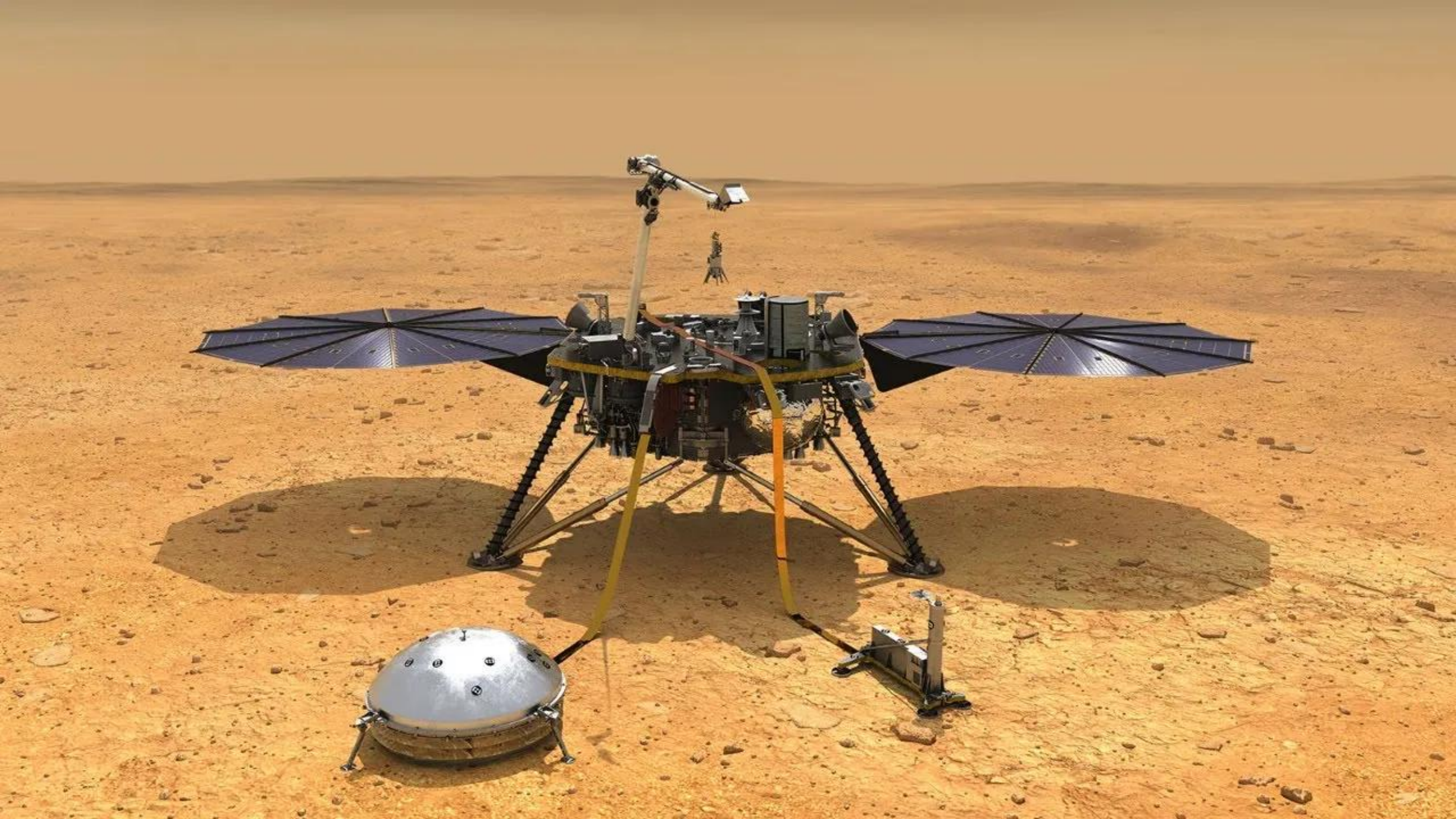

1
00:01:57,130 --> 00:00:10,790
[Music]

2
00:03:02,830 --> 00:01:57,140
[Applause]

3
00:03:02,840 --> 00:03:16,310
uh

4
00:03:52,310 --> 00:03:50,850
[Music]

5
00:04:16,740 --> 00:03:52,320
[Applause]

6
00:04:17,009 --> 00:04:16,750
[Music]

7
00:04:40,830 --> 00:04:17,019
[Applause]

8
00:05:30,710 --> 00:04:42,510
do

9
00:05:34,870 --> 00:05:33,110
well today's discussion about nasa's

10
00:05:37,189 --> 00:05:34,880
insight lander

11
00:05:38,550 --> 00:05:37,199
before insight touched down on mars in

12
00:05:41,350 --> 00:05:38,560
2018

13
00:05:42,390 --> 00:05:41,360

rovers and orbiters mainly focused on

14
00:05:45,909 --> 00:05:42,400
the surface

15
00:05:47,590 --> 00:05:45,919
of the planet now insight is giving

16
00:05:50,629 --> 00:05:47,600
scientists the first look

17
00:05:53,270 --> 00:05:50,639
at the heart of mars with

18
00:05:53,990 --> 00:05:53,280
three new studies about its crust mantle

19
00:05:57,110 --> 00:05:54,000
and core

20
00:05:58,870 --> 00:05:57,120
published just this week

21
00:06:00,550 --> 00:05:58,880
the insight team members joining us

22
00:06:03,350 --> 00:06:00,560
today are

23
00:06:05,510 --> 00:06:03,360
mark panning of nasa's jet propulsion

24
00:06:08,230 --> 00:06:05,520
laboratory

25
00:06:09,830 --> 00:06:08,240
sabina stanley of johns hopkins

26
00:06:13,189 --> 00:06:09,840
university

27
00:06:16,469 --> 00:06:13,199
and amir khan of eth zurich

28
00:06:17,270 --> 00:06:16,479
and the university of zurich and i'm

29
00:06:20,790 --> 00:06:17,280
your host

30
00:06:21,830 --> 00:06:20,800
raquel villanueva you can use the ask

31
00:06:24,710 --> 00:06:21,840
nasa

32
00:06:25,270 --> 00:06:24,720
on facebook youtube and twitter to ask

33
00:06:28,550 --> 00:06:25,280
the team

34
00:06:29,270 --> 00:06:28,560
any questions now before we get to

35
00:06:31,909 --> 00:06:29,280
indians

36
00:06:33,189 --> 00:06:31,919
mark can you give us a quick recap of

37
00:06:35,110 --> 00:06:33,199
insight's mission

38
00:06:37,510 --> 00:06:35,120

for those who aren't really familiar

39
00:06:40,230 --> 00:06:37,520
with the lander

40
00:06:41,670 --> 00:06:40,240
yeah thanks raquel um if you bring up

41
00:06:45,110 --> 00:06:41,680
image one

42
00:06:47,270 --> 00:06:45,120
uh you can see that uh uh inside

43
00:06:49,029 --> 00:06:47,280
a lander we're not a rover we're not

44
00:06:50,150 --> 00:06:49,039
moving around we're standing still so

45
00:06:52,629 --> 00:06:50,160
that we can record

46
00:06:53,589 --> 00:06:52,639
uh the things we want to record um and

47
00:06:56,230 --> 00:06:53,599
we landed with

48
00:06:56,950 --> 00:06:56,240
a bunch of instruments that are aimed at

49
00:06:59,029 --> 00:06:56,960
as raquel

50
00:07:00,390 --> 00:06:59,039
said looking at the inside of mars

51
00:07:01,830 --> 00:07:00,400
rather than the surface of mars

52
00:07:03,589 --> 00:07:01,840
and we're the first mission that's

53
00:07:05,270 --> 00:07:03,599
really focused on understanding the

54
00:07:07,189 --> 00:07:05,280
interior of mars

55
00:07:09,029 --> 00:07:07,199
um we landed with a lot of instruments

56
00:07:10,710 --> 00:07:09,039
as i said but uh today we're only going

57
00:07:11,830 --> 00:07:10,720
to be talking about results from the

58
00:07:14,150 --> 00:07:11,840
seismometer

59
00:07:16,230 --> 00:07:14,160
which uh in the image you could see is

60
00:07:17,510 --> 00:07:16,240
is sitting out in front of the lander

61
00:07:19,990 --> 00:07:17,520
underneath that thing that kind of looks

62
00:07:23,029 --> 00:07:20,000
like an upside down pie plate

63
00:07:24,629 --> 00:07:23,039

and uh so as i said we're trying to

64
00:07:27,749 --> 00:07:24,639
understand the inside of mars

65
00:07:28,870 --> 00:07:27,759
and the the plan there the the the goal

66
00:07:30,309 --> 00:07:28,880
is to understand

67
00:07:32,710 --> 00:07:30,319
the insides of that we can look at the

68
00:07:33,350 --> 00:07:32,720
formation and evolution of mars and the

69
00:07:35,029 --> 00:07:33,360
overall

70
00:07:36,790 --> 00:07:35,039
reason why we want to do that is because

71
00:07:39,749 --> 00:07:36,800
mars is one of our four

72
00:07:41,110 --> 00:07:39,759
rocky planets of the solar system which

73
00:07:44,629 --> 00:07:41,120
also includes earth

74
00:07:47,110 --> 00:07:44,639
venus and mercury and by going from

75
00:07:47,670 --> 00:07:47,120
cartoon understanding of what the inside

76
00:07:51,830 --> 00:07:47,680
of

77
00:07:54,150 --> 00:07:51,840
numbers on it as we've done in the

78
00:07:56,710 --> 00:07:54,160
studies that that came out this week

79
00:07:58,710 --> 00:07:56,720
we are able to you know really expand

80
00:08:00,629 --> 00:07:58,720
the family tree of understanding how

81
00:08:03,749 --> 00:08:00,639
these rocky planets form and how they're

82
00:08:05,189 --> 00:08:03,759
similar and how they're different it's

83
00:08:08,230 --> 00:08:05,199
good to hear our family tree

84
00:08:10,790 --> 00:08:08,240
is now growing now before we

85
00:08:11,270 --> 00:08:10,800
get to additional questions i want to

86
00:08:14,390 --> 00:08:11,280
ask

87
00:08:16,790 --> 00:08:14,400
each of you the same question

88
00:08:17,749 --> 00:08:16,800

what was one of the most intriguing

89
00:08:20,790 --> 00:08:17,759
results

90
00:08:23,350 --> 00:08:20,800
for you personally uh can we start with

91
00:08:26,469 --> 00:08:25,510
thanks for calling you know what that

92
00:08:28,629 --> 00:08:26,479
that's a really

93
00:08:30,070 --> 00:08:28,639
difficult question actually simply

94
00:08:31,990 --> 00:08:30,080
because that we have made so many

95
00:08:35,350 --> 00:08:32,000
interesting discoveries

96
00:08:37,269 --> 00:08:35,360
um but if i have to single out one thing

97
00:08:38,870 --> 00:08:37,279
then it would have to be the observation

98
00:08:41,829 --> 00:08:38,880
that we have actually you know we have

99
00:08:43,990 --> 00:08:41,839
landed an entire geophysical laboratory

100
00:08:46,150 --> 00:08:44,000
including a highly sensitive seismometer

101
00:08:48,470 --> 00:08:46,160
on the surface of moss

102
00:08:50,710 --> 00:08:48,480
and that that seismometer has actually

103
00:08:52,630 --> 00:08:50,720
been able to detect mars quakes

104
00:08:54,550 --> 00:08:52,640
which allowed us to look inside the

105
00:08:56,230 --> 00:08:54,560
planet and from which we have learned

106
00:09:00,470 --> 00:08:56,240
quite a bit about its interior

107
00:09:02,470 --> 00:09:00,480
for example insight has confirmed our

108
00:09:05,670 --> 00:09:02,480
view that mars is a planet

109
00:09:08,150 --> 00:09:05,680
that was once probably completely molten

110
00:09:08,870 --> 00:09:08,160
as a result of which it's separated into

111
00:09:11,509 --> 00:09:08,880
a crust

112
00:09:12,790 --> 00:09:11,519
a mantle and a core that's what we see

113
00:09:14,710 --> 00:09:12,800

on this image here

114
00:09:17,110 --> 00:09:14,720
and the most fascinating thing is that

115
00:09:19,910 --> 00:09:17,120
we have now been able to put numbers

116
00:09:22,310 --> 00:09:19,920
on these units crust maple and core with

117
00:09:24,150 --> 00:09:22,320
the data that we have gotten from inside

118
00:09:26,150 --> 00:09:24,160
we know the crustal thickness we know

119
00:09:27,509 --> 00:09:26,160
the thickness of the mantle and we know

120
00:09:30,949 --> 00:09:27,519
the core size

121
00:09:33,990 --> 00:09:30,959
and its density its mass and

122
00:09:35,509 --> 00:09:34,000
of course their properties and all of

123
00:09:37,750 --> 00:09:35,519
this is really what we need

124
00:09:40,230 --> 00:09:37,760
in order for us to move on to what i

125
00:09:42,470 --> 00:09:40,240
would call the next stage

126
00:09:43,269 --> 00:09:42,480
which is to say something about how ma

127
00:09:46,389 --> 00:09:43,279
is formed

128
00:09:48,470 --> 00:09:46,399
and evolved which is really the main

129
00:09:49,670 --> 00:09:48,480
reason why we put mars on the planet in

130
00:09:52,070 --> 00:09:49,680
the first place

131
00:09:53,829 --> 00:09:52,080
i think this is to me the most single

132
00:09:55,990 --> 00:09:53,839
outstanding thing

133
00:09:57,190 --> 00:09:56,000
also because it paves the way for you

134
00:10:00,070 --> 00:09:57,200
know future

135
00:10:01,430 --> 00:10:00,080
missions future seismological missions

136
00:10:04,949 --> 00:10:01,440
be it single station

137
00:10:08,790 --> 00:10:04,959
because we know it works that is

138
00:10:11,110 --> 00:10:08,800

fascinating and what about you sabina

139
00:10:12,790 --> 00:10:11,120
thanks for cal so for me i think this

140
00:10:13,910 --> 00:10:12,800
would have to be the fact that the core

141
00:10:15,590 --> 00:10:13,920
is actually quite

142
00:10:17,269 --> 00:10:15,600
large it's on the high end of what we

143
00:10:19,269 --> 00:10:17,279
expected before the mission

144
00:10:21,030 --> 00:10:19,279
and the density of the core is actually

145
00:10:22,150 --> 00:10:21,040
on the low end of what we expected

146
00:10:23,750 --> 00:10:22,160
before the mission

147
00:10:25,750 --> 00:10:23,760
so the reason those are interesting is

148
00:10:26,069 --> 00:10:25,760
because there are big implications for

149
00:10:29,430 --> 00:10:26,079
how

150
00:10:32,550 --> 00:10:29,440
mars created its magnetic field long ago

151
00:10:34,230 --> 00:10:32,560
so today on the surface of mars we see

152
00:10:35,350 --> 00:10:34,240
that the crustal rocks some of them are

153
00:10:38,470 --> 00:10:35,360
magnetized

154
00:10:40,949 --> 00:10:38,480
formed while mars had an

155
00:10:41,750 --> 00:10:40,959
active dynamo and that happened over

156
00:10:44,550 --> 00:10:41,760
three and a half

157
00:10:46,790 --> 00:10:44,560
billion years ago but now that we know

158
00:10:48,790 --> 00:10:46,800
the size of the core and we have some

159
00:10:50,790 --> 00:10:48,800
information about the composition of the

160
00:10:53,430 --> 00:10:50,800
core from the density measurements

161
00:10:55,030 --> 00:10:53,440
we can start thinking about how mars

162
00:10:57,190 --> 00:10:55,040
dynamo worked

163
00:10:58,949 --> 00:10:57,200

and that's exciting because a global

164
00:11:00,550 --> 00:10:58,959
magnetic field that was created by the

165
00:11:02,870 --> 00:11:00,560
dynamo

166
00:11:03,670 --> 00:11:02,880
that has important implications for mars

167
00:11:05,269 --> 00:11:03,680
atmosphere

168
00:11:07,430 --> 00:11:05,279
and as soon as you start mentioning

169
00:11:09,990 --> 00:11:07,440
atmospheres you start

170
00:11:10,710 --> 00:11:10,000
connecting to whether or not mars was

171
00:11:14,870 --> 00:11:10,720
habitable

172
00:11:16,790 --> 00:11:14,880
in its early life habitability is on

173
00:11:19,750 --> 00:11:16,800
everyone's mind when you talk about mars

174
00:11:21,430 --> 00:11:19,760
and mark what about you

175
00:11:23,350 --> 00:11:21,440
yeah to me what's actually most

176
00:11:25,350 --> 00:11:23,360
fascinating is what we've done with

177
00:11:27,509 --> 00:11:25,360
events that are actually pretty small

178
00:11:28,949 --> 00:11:27,519
um the the biggest events that we're

179
00:11:31,190 --> 00:11:28,959
talking about and that

180
00:11:33,030 --> 00:11:31,200
that we've used to to nail down the

181
00:11:34,470 --> 00:11:33,040
details of the crest mantle and core in

182
00:11:36,230 --> 00:11:34,480
the studies that came out

183
00:11:37,509 --> 00:11:36,240
um the biggest ones have been less than

184
00:11:39,030 --> 00:11:37,519
magnitude four

185
00:11:40,550 --> 00:11:39,040
and so these are the kind of events that

186
00:11:41,829 --> 00:11:40,560
here in california where i'm at

187
00:11:43,430 --> 00:11:41,839
there's a good chance you wouldn't even

188
00:11:44,069 --> 00:11:43,440

feel it unless you were pretty close to

189
00:11:46,949 --> 00:11:44,079
it

190
00:11:47,829 --> 00:11:46,959
um and so you know the the the fact that

191
00:11:49,269 --> 00:11:47,839
we've been able to

192
00:11:51,430 --> 00:11:49,279
get all these details is really

193
00:11:52,230 --> 00:11:51,440
interesting and it's and the the fact

194
00:11:53,750 --> 00:11:52,240
that these

195
00:11:55,509 --> 00:11:53,760
events are all more than a thousand

196
00:11:56,949 --> 00:11:55,519
miles away and we've still been able to

197
00:11:58,790 --> 00:11:56,959
measure them is something we could only

198
00:12:01,910 --> 00:11:58,800
do on mars and not on earth

199
00:12:03,750 --> 00:12:01,920
and that's because on earth the

200
00:12:05,590 --> 00:12:03,760
background is noisy and it's because of

201
00:12:06,790 --> 00:12:05,600
the oceans the oceans are always

202
00:12:07,990 --> 00:12:06,800
pounding and even if you're sitting in

203
00:12:09,670 --> 00:12:08,000
the middle of siberia

204
00:12:11,110 --> 00:12:09,680
well away from any oceans you're always

205
00:12:13,110 --> 00:12:11,120
hearing the noise of the oceans

206
00:12:14,550 --> 00:12:13,120
on mars you're not hearing that at all

207
00:12:16,310 --> 00:12:14,560
because there's no oceans

208
00:12:17,590 --> 00:12:16,320
and that means that in the frequency

209
00:12:19,110 --> 00:12:17,600
band that we're looking at where we're

210
00:12:21,269 --> 00:12:19,120
making these measurements

211
00:12:22,790 --> 00:12:21,279
uh mars is probably two orders of

212
00:12:25,670 --> 00:12:22,800
magnitude quieter than

213
00:12:27,190 --> 00:12:25,680

anywhere on earth um and so we've been

214
00:12:28,389 --> 00:12:27,200
able to make some really astounding

215
00:12:30,870 --> 00:12:28,399
measurements and really

216
00:12:32,389 --> 00:12:30,880
get at the the things we wanted to do

217
00:12:35,350 --> 00:12:32,399
with this mission with events that are

218
00:12:37,350 --> 00:12:35,360
actually pretty small

219
00:12:39,110 --> 00:12:37,360
which makes me wonder about the core

220
00:12:42,150 --> 00:12:39,120
amir you study the core

221
00:12:47,110 --> 00:12:42,160
uh how does studying it help scientists

222
00:12:53,110 --> 00:12:50,550
well raquel you know the core is really

223
00:12:55,110 --> 00:12:53,120
the heart of the planet so to speak

224
00:12:57,430 --> 00:12:55,120
because it contains the clues to mars

225
00:13:00,710 --> 00:12:57,440
formation

226
00:13:04,550 --> 00:13:00,720
it informs us about the how

227
00:13:06,949 --> 00:13:04,560
and when and of what did mars form

228
00:13:07,910 --> 00:13:06,959
you know mars like earth heated up as it

229
00:13:10,310 --> 00:13:07,920
formed from the

230
00:13:12,310 --> 00:13:10,320
dust and the larger clumps of material

231
00:13:15,590 --> 00:13:12,320
that was around in the early syste

232
00:13:17,670 --> 00:13:15,600
solar system and and

233
00:13:19,430 --> 00:13:17,680
over the next few million years the

234
00:13:21,670 --> 00:13:19,440
planet sort of separated

235
00:13:24,550 --> 00:13:21,680
into a cross mantle and core which is

236
00:13:27,670 --> 00:13:24,560
what we saw on image two here please

237
00:13:31,110 --> 00:13:27,680
um and this um

238
00:13:32,710 --> 00:13:31,120

this observation tells us that mars was

239
00:13:35,430 --> 00:13:32,720
most likely completely molten

240
00:13:36,230 --> 00:13:35,440
for it to form such a large iron nickel

241
00:13:39,189 --> 00:13:36,240
core

242
00:13:40,470 --> 00:13:39,199
as the heavy stuff would you know sink

243
00:13:43,030 --> 00:13:40,480
relatively easily

244
00:13:44,389 --> 00:13:43,040
toward the center of the planet that's

245
00:13:47,110 --> 00:13:44,399
the howl

246
00:13:48,230 --> 00:13:47,120
next we have learned from insight that

247
00:13:50,949 --> 00:13:48,240
the density of the

248
00:13:52,949 --> 00:13:50,959
core that is the mass of the core is low

249
00:13:55,910 --> 00:13:52,959
compared to what we'd expect

250
00:13:57,590 --> 00:13:55,920
if it was made made of of nick iron

251
00:13:59,590 --> 00:13:57,600
nickel only

252
00:14:01,509 --> 00:13:59,600
this implies that it you know the core

253
00:14:04,710 --> 00:14:01,519
of mars must contain

254
00:14:05,829 --> 00:14:04,720
a lot of light elements such as sulfur

255
00:14:08,790 --> 00:14:05,839
and carbon and

256
00:14:10,310 --> 00:14:08,800
oxygen and hydrogen because that's the

257
00:14:11,910 --> 00:14:10,320
only way to make an iron

258
00:14:14,710 --> 00:14:11,920
you know a heavy iron nickel core

259
00:14:17,269 --> 00:14:14,720
lighter now this in turn suggests that

260
00:14:19,670 --> 00:14:17,279
mars probably form while the dust

261
00:14:21,110 --> 00:14:19,680
in the early solar system which

262
00:14:22,150 --> 00:14:21,120
basically consists of a lot of these

263
00:14:25,750 --> 00:14:22,160

light elements

264
00:14:27,430 --> 00:14:25,760
was still around and that suggests again

265
00:14:29,189 --> 00:14:27,440
that mars must have formed right at the

266
00:14:32,470 --> 00:14:29,199
start of the solar system

267
00:14:33,110 --> 00:14:32,480
that's the when as for the what is mars

268
00:14:37,030 --> 00:14:33,120
made

269
00:14:39,269 --> 00:14:37,040
it it seems very difficult to form mars

270
00:14:41,189 --> 00:14:39,279
from the same material as the earth the

271
00:14:43,990 --> 00:14:41,199
need for you know these light elements

272
00:14:45,269 --> 00:14:44,000
almost begs for material that is further

273
00:14:47,269 --> 00:14:45,279
from the sun

274
00:14:49,269 --> 00:14:47,279
because the material will bring with it

275
00:14:52,069 --> 00:14:49,279
more of the light elements that we need

276
00:14:53,030 --> 00:14:52,079
to lower the mass of the core and

277
00:14:54,949 --> 00:14:53,040
incidentally the

278
00:14:57,189 --> 00:14:54,959
you know these light elements in the

279
00:14:58,629 --> 00:14:57,199
core also explains why the core of mars

280
00:15:00,870 --> 00:14:58,639
is liquid today

281
00:15:02,310 --> 00:15:00,880
simply because the white elements lower

282
00:15:05,670 --> 00:15:02,320
the freezing point of

283
00:15:07,670 --> 00:15:05,680
the liquid or of the iron nickel core

284
00:15:08,870 --> 00:15:07,680
you know like the freezing of water is

285
00:15:12,870 --> 00:15:08,880
lowered

286
00:15:15,030 --> 00:15:12,880
when you mix it with salt for example

287
00:15:15,910 --> 00:15:15,040
some great details about the core now

288
00:15:17,509 --> 00:15:15,920

sabina

289
00:15:19,189 --> 00:15:17,519
what are the similarities and

290
00:15:22,310 --> 00:15:19,199
differences in how

291
00:15:24,069 --> 00:15:22,320
earth and mars work

292
00:15:25,829 --> 00:15:24,079
yeah great question raquel so we can

293
00:15:28,710 --> 00:15:25,839
look at image

294
00:15:29,350 --> 00:15:28,720
3 now so you can see in the image mars

295
00:15:31,910 --> 00:15:29,360
is about

296
00:15:33,189 --> 00:15:31,920
half the size of earth and in some ways

297
00:15:34,310 --> 00:15:33,199
the planets actually behave very

298
00:15:36,629 --> 00:15:34,320
differently

299
00:15:38,230 --> 00:15:36,639
so the outer rigid layer of rocky

300
00:15:40,310 --> 00:15:38,240
planets that's called the lithosphere

301
00:15:41,509 --> 00:15:40,320
and on earth the lithosphere is kind of

302
00:15:43,829 --> 00:15:41,519
thin and it's

303
00:15:44,790 --> 00:15:43,839
broken up into plates marked with these

304
00:15:47,430 --> 00:15:44,800
lines here

305
00:15:49,749 --> 00:15:47,440
now those plates move relative to each

306
00:15:51,110 --> 00:15:49,759
other that's known as plate tectonics

307
00:15:52,870 --> 00:15:51,120
and it's the motion of these plates

308
00:15:54,230 --> 00:15:52,880
that's largely responsible for most of

309
00:15:55,990 --> 00:15:54,240
the earthquakes

310
00:15:58,230 --> 00:15:56,000
so for example on the west coast of the

311
00:16:00,310 --> 00:15:58,240
us you know about the san andreas fault

312
00:16:01,590 --> 00:16:00,320
which is a boundary between two plates

313
00:16:03,590 --> 00:16:01,600

that are moving against each other and

314
00:16:05,749 --> 00:16:03,600
that causes lots of earthquakes

315
00:16:07,030 --> 00:16:05,759
there are also strong earthquakes at

316
00:16:09,189 --> 00:16:07,040
subduction zones

317
00:16:10,150 --> 00:16:09,199
that's where one plate descends back

318
00:16:12,470 --> 00:16:10,160
into the mantle

319
00:16:14,629 --> 00:16:12,480
underneath another that example for

320
00:16:17,590 --> 00:16:14,639
example happens around the pacific rim

321
00:16:18,870 --> 00:16:17,600
now because mars is smaller it has a

322
00:16:21,189 --> 00:16:18,880
thicker lithosphere

323
00:16:23,269 --> 00:16:21,199
and it's much harder to get the surface

324
00:16:24,470 --> 00:16:23,279
to break apart and descend back into the

325
00:16:26,870 --> 00:16:24,480
planet

326
00:16:27,670 --> 00:16:26,880
that means mars doesn't have plate

327
00:16:30,629 --> 00:16:27,680
tectonics

328
00:16:31,430 --> 00:16:30,639
mars is a one plate planet so we don't

329
00:16:34,150 --> 00:16:31,440
expect

330
00:16:34,790 --> 00:16:34,160
mars quakes to be as large or as

331
00:16:36,230 --> 00:16:34,800
frequent

332
00:16:39,430 --> 00:16:36,240
as earthquakes and that's how the

333
00:16:41,189 --> 00:16:39,440
planets are actually quite different

334
00:16:43,189 --> 00:16:41,199
it's fascinating to think of mars as a

335
00:16:45,430 --> 00:16:43,199
one-plate planet

336
00:16:47,990 --> 00:16:45,440
and kind of speaking about quakes mark

337
00:16:51,269 --> 00:16:48,000
can you tell us what tools insight uses

338
00:16:54,790 --> 00:16:51,279

to detect marsquakes

339
00:16:56,870 --> 00:16:54,800
yeah uh thanks raquel so the um the the

340
00:16:57,829 --> 00:16:56,880
instrument we're using for for these

341
00:16:59,430 --> 00:16:57,839
studies is

342
00:17:01,110 --> 00:16:59,440
called the the very broadband

343
00:17:03,829 --> 00:17:01,120
seismometer um

344
00:17:04,150 --> 00:17:03,839
and uh it's supplied by the the french

345
00:17:06,870 --> 00:17:04,160
and

346
00:17:08,470 --> 00:17:06,880
um the image you see on the screen here

347
00:17:10,390 --> 00:17:08,480
image five that's the

348
00:17:11,750 --> 00:17:10,400
that's a kind of a cross section of what

349
00:17:13,669 --> 00:17:11,760
this is and um

350
00:17:15,029 --> 00:17:13,679
it's a there's a lot of complicated

351
00:17:15,750 --> 00:17:15,039
things happening in there but there's

352
00:17:18,949 --> 00:17:15,760
layers

353
00:17:21,350 --> 00:17:18,959
protecting the instrument from

354
00:17:23,029 --> 00:17:21,360
wind and thermal noise temperature

355
00:17:24,390 --> 00:17:23,039
changes all of that that cause noise in

356
00:17:25,189 --> 00:17:24,400
the seismometer and the seismometer

357
00:17:26,630 --> 00:17:25,199
itself is

358
00:17:28,549 --> 00:17:26,640
deep in the middle of it some of the

359
00:17:29,909 --> 00:17:28,559
kind of metal complicated metal bits

360
00:17:32,310 --> 00:17:29,919
there in the middle

361
00:17:33,270 --> 00:17:32,320
and this is an extremely sensitive

362
00:17:34,870 --> 00:17:33,280
instrument it's

363
00:17:38,390 --> 00:17:34,880

capable of measuring motions that are

364
00:17:41,029 --> 00:17:38,400
the scale of a hydrogen atom so this is

365
00:17:42,710 --> 00:17:41,039
amazingly sensitive that we're that that

366
00:17:43,990 --> 00:17:42,720
we can do and we we need to do that

367
00:17:45,830 --> 00:17:44,000
because like i said

368
00:17:47,350 --> 00:17:45,840
um these are small events that we're

369
00:17:48,789 --> 00:17:47,360
measuring from more than a thousand

370
00:17:49,830 --> 00:17:48,799
miles away so we need to have that

371
00:17:52,630 --> 00:17:49,840
really sensitive

372
00:17:53,750 --> 00:17:52,640
instrument and if you go to image four

373
00:17:55,830 --> 00:17:53,760
you can see

374
00:17:57,430 --> 00:17:55,840
um the the seismo on the left you can

375
00:17:59,350 --> 00:17:57,440
see the seismometer there and it's uh

376
00:18:00,549 --> 00:17:59,360
native habitat on the surface of mars

377
00:18:02,070 --> 00:18:00,559
making its measurements

378
00:18:04,390 --> 00:18:02,080
and the measurements we get back look

379
00:18:05,430 --> 00:18:04,400
like the the what we call the seismogram

380
00:18:06,950 --> 00:18:05,440
on the right

381
00:18:08,630 --> 00:18:06,960
um they're just wiggles showing the

382
00:18:10,950 --> 00:18:08,640
ground motion up and down

383
00:18:12,630 --> 00:18:10,960
um side to side and uh you can see

384
00:18:13,029 --> 00:18:12,640
there's two big peaks on there those are

385
00:18:15,110 --> 00:18:13,039
the p

386
00:18:18,150 --> 00:18:15,120
s waves for those who have have studied

387
00:18:19,029 --> 00:18:18,160
uh intro seismology or intro geology at

388
00:18:21,350 --> 00:18:19,039

some point

389
00:18:22,549 --> 00:18:21,360
and the studies we that we're talking

390
00:18:25,029 --> 00:18:22,559
about this week

391
00:18:26,710 --> 00:18:25,039
um are all taking really smaller wiggles

392
00:18:28,150 --> 00:18:26,720
that are after those big arrivals in

393
00:18:29,830 --> 00:18:28,160
order to get at the

394
00:18:31,590 --> 00:18:29,840
the structure of the deep interior of

395
00:18:33,110 --> 00:18:31,600
mars

396
00:18:34,950 --> 00:18:33,120
and i have one more question about those

397
00:18:37,750 --> 00:18:34,960
wiggles sabina

398
00:18:39,669 --> 00:18:37,760
where are most quakes coming from on

399
00:18:41,990 --> 00:18:39,679
mars

400
00:18:43,750 --> 00:18:42,000
yeah great question raquel so we can

401
00:18:45,669 --> 00:18:43,760
actually look at image six now

402
00:18:47,590 --> 00:18:45,679
so most of the quakes we've observed

403
00:18:49,669 --> 00:18:47,600
appear to come from one region of mars

404
00:18:51,350 --> 00:18:49,679
and it's called cerberus fosse

405
00:18:53,430 --> 00:18:51,360
and this region is about a thousand

406
00:18:55,350 --> 00:18:53,440
miles east of the inside lander

407
00:18:57,029 --> 00:18:55,360
now the fosse occur because forces are

408
00:18:58,710 --> 00:18:57,039
kind of pulling the crust apart a bit

409
00:18:59,830 --> 00:18:58,720
there and that's causing the cracks that

410
00:19:01,190 --> 00:18:59,840
we see

411
00:19:03,270 --> 00:19:01,200
now before the mission we thought this

412
00:19:06,070 --> 00:19:03,280
region might actually be tectonically

413
00:19:07,669 --> 00:19:06,080

active and have things like earthquakes

414
00:19:09,430 --> 00:19:07,679
because of the shifting and cracking

415
00:19:10,789 --> 00:19:09,440
that we were expecting and we thought

416
00:19:12,870 --> 00:19:10,799
this because we've actually seen

417
00:19:14,390 --> 00:19:12,880
trails left from boulders that are

418
00:19:17,029 --> 00:19:14,400
rolling down the sides of the cliffs

419
00:19:18,390 --> 00:19:17,039
that's what's shown in this image here

420
00:19:20,150 --> 00:19:18,400
there are also signs that this region

421
00:19:21,830 --> 00:19:20,160
was actually volcanically active quite

422
00:19:23,029 --> 00:19:21,840
recently maybe tens of thousands to

423
00:19:26,070 --> 00:19:23,039
millions of years ago

424
00:19:28,150 --> 00:19:26,080
which for geology that's quite recent

425
00:19:29,510 --> 00:19:28,160
now there's another region of mars that

426
00:19:31,270 --> 00:19:29,520
we thought we might see

427
00:19:33,510 --> 00:19:31,280
mars quakes from and that's tharsis

428
00:19:35,270 --> 00:19:33,520
starsus is that giant volcanic province

429
00:19:36,470 --> 00:19:35,280
that has all the really big volcanoes on

430
00:19:38,549 --> 00:19:36,480
mars

431
00:19:39,990 --> 00:19:38,559
and it turns out now that we've actually

432
00:19:41,430 --> 00:19:40,000
narrowed down the size of the core and

433
00:19:43,750 --> 00:19:41,440
we know that it's quite big

434
00:19:46,310 --> 00:19:43,760
it makes sense that we haven't

435
00:19:48,710 --> 00:19:46,320
identified any quakes from there

436
00:19:50,549 --> 00:19:48,720
and that's because tharsis ends up in a

437
00:19:52,950 --> 00:19:50,559
region called the shadow zone

438
00:19:54,870 --> 00:19:52,960

of the insight seismometer so this is a

439
00:19:56,070 --> 00:19:54,880
region where we actually can't detect

440
00:19:59,270 --> 00:19:56,080
seismic waves

441
00:20:01,590 --> 00:19:59,280
if an earth a marsquake occurs

442
00:20:03,590 --> 00:20:01,600
near tharsis because the material

443
00:20:06,390 --> 00:20:03,600
properties of mars mantle cause all the

444
00:20:08,630 --> 00:20:06,400
waves to deflect away from

445
00:20:10,470 --> 00:20:08,640
the insight lander so it's not

446
00:20:12,630 --> 00:20:10,480
surprising now that we haven't yet

447
00:20:13,990 --> 00:20:12,640
seen any quakes from the tharsis region

448
00:20:16,310 --> 00:20:14,000
even though we expect it might be

449
00:20:19,510 --> 00:20:16,320
tectonically active

450
00:20:21,750 --> 00:20:19,520
yeah this is kind of a great segue into

451
00:20:23,270 --> 00:20:21,760
viewer questions that we have now if

452
00:20:24,789 --> 00:20:23,280
anyone watching has a question they'd

453
00:20:28,070 --> 00:20:24,799
like to ask they can use

454
00:20:31,590 --> 00:20:28,080
the ask nasa hashtag to submit it and

455
00:20:34,630 --> 00:20:31,600
first up we have

456
00:20:37,110 --> 00:20:34,640
fred on facebook who asks how does the

457
00:20:39,909 --> 00:20:37,120
recorded martian seismic activity

458
00:20:41,990 --> 00:20:39,919
compare with earth's mark would you like

459
00:20:45,350 --> 00:20:42,000
to take that

460
00:20:48,549 --> 00:20:45,360
yeah sure um so uh as

461
00:20:51,350 --> 00:20:48,559
as sabine pointed out earlier earth has

462
00:20:52,070 --> 00:20:51,360
plate tectonics and that causes really

463
00:20:54,149 --> 00:20:52,080

big

464
00:20:56,149 --> 00:20:54,159
earthquakes that happen particularly in

465
00:20:58,149 --> 00:20:56,159
places like subduction zones

466
00:21:00,230 --> 00:20:58,159
where where the plates running under

467
00:21:01,909 --> 00:21:00,240
another one mars doesn't have that so we

468
00:21:03,510 --> 00:21:01,919
don't see any of the big quakes

469
00:21:05,190 --> 00:21:03,520
if you look at the total amount of

470
00:21:07,990 --> 00:21:05,200
quakes we see um it's

471
00:21:09,190 --> 00:21:08,000
it's um quite a bit less than we see

472
00:21:11,270 --> 00:21:09,200
even in the quiet

473
00:21:12,870 --> 00:21:11,280
inner portions of the plates that aren't

474
00:21:13,750 --> 00:21:12,880
near the edges we're seeing less size

475
00:21:15,190 --> 00:21:13,760
missing that

476
00:21:16,870 --> 00:21:15,200
but we are seeing a little more size

477
00:21:18,230 --> 00:21:16,880
missing than we saw on the moon with a

478
00:21:21,510 --> 00:21:18,240
with with apollo

479
00:21:22,950 --> 00:21:21,520
seismometers um and so uh overall it's a

480
00:21:25,350 --> 00:21:22,960
it's a pretty small number

481
00:21:26,470 --> 00:21:25,360
um and uh at this point as i said we

482
00:21:28,470 --> 00:21:26,480
haven't seen anything

483
00:21:29,990 --> 00:21:28,480
bigger than a magnitude 4 whereas on

484
00:21:31,430 --> 00:21:30,000
earth you get events that are bigger

485
00:21:33,909 --> 00:21:31,440
than magnitude eight or nine

486
00:21:35,990 --> 00:21:33,919
and um if you don't know how magnitude

487
00:21:37,270 --> 00:21:36,000
scales work that's a really really big

488
00:21:41,350 --> 00:21:37,280

difference in energy so

489
00:21:43,909 --> 00:21:41,360
uh mars is much much quieter than earth

490
00:21:44,789 --> 00:21:43,919
and then we have another one that seems

491
00:21:48,390 --> 00:21:44,799
kind of

492
00:21:50,950 --> 00:21:48,400
fun what about meteorites

493
00:21:52,230 --> 00:21:50,960
can robert on twitter ask can you detect

494
00:21:56,830 --> 00:21:52,240
meteor strikes

495
00:22:00,470 --> 00:21:58,950
quake

496
00:22:02,950 --> 00:22:00,480
mark would you want to take that one too

497
00:22:05,990 --> 00:22:02,960
yeah i i want to dominate all the

498
00:22:08,310 --> 00:22:06,000
the answers here but um so uh

499
00:22:10,390 --> 00:22:08,320
going into the mission we had um uh

500
00:22:12,390 --> 00:22:10,400
hoped to see meteor strikes um

501
00:22:13,830 --> 00:22:12,400
see impacts um those are the kinds of

502
00:22:15,430 --> 00:22:13,840
things you can detect if you look on the

503
00:22:16,470 --> 00:22:15,440
moon we actually detected a lot of

504
00:22:19,510 --> 00:22:16,480
impacts

505
00:22:20,630 --> 00:22:19,520
um with with apollo seismometers um at

506
00:22:23,830 --> 00:22:20,640
this point

507
00:22:24,470 --> 00:22:23,840
we have not uh uh conclusively seen any

508
00:22:26,630 --> 00:22:24,480
impacts

509
00:22:29,029 --> 00:22:26,640
um and uh that that that's a little

510
00:22:32,390 --> 00:22:29,039
disappointing but the impact rates

511
00:22:33,190 --> 00:22:32,400
not very high and um and mars does have

512
00:22:35,430 --> 00:22:33,200
a thin

513
00:22:37,350 --> 00:22:35,440

atmosphere that filters out uh some of

514
00:22:38,149 --> 00:22:37,360
the impacts so at this point we haven't

515
00:22:40,149 --> 00:22:38,159
seen one

516
00:22:41,750 --> 00:22:40,159
um but that doesn't mean we can't uh we

517
00:22:43,270 --> 00:22:41,760
have we we we have

518
00:22:44,870 --> 00:22:43,280
estimations of all sorts of things and

519
00:22:47,990 --> 00:22:44,880
we're actually uh looking at

520
00:22:49,909 --> 00:22:48,000
uh images from from various orbiters

521
00:22:52,470 --> 00:22:49,919
around mars that are always looking for

522
00:22:54,310 --> 00:22:52,480
fresh impact craters by comparing images

523
00:22:56,230 --> 00:22:54,320
and whenever any of those are seen we

524
00:22:58,950 --> 00:22:56,240
try to see if we can see it in the data

525
00:23:02,149 --> 00:22:58,960
um so thus far we haven't but uh trust

526
00:23:05,350 --> 00:23:02,159
me we're looking very closely

527
00:23:06,710 --> 00:23:05,360
we'll see one day and cnn news

528
00:23:08,549 --> 00:23:06,720
oh did amir would you like to add

529
00:23:08,950 --> 00:23:08,559
something yeah yeah i just wanted to say

530
00:23:10,710 --> 00:23:08,960
i mean

531
00:23:12,789 --> 00:23:10,720
like just to pick up on mark's last

532
00:23:14,950 --> 00:23:12,799
point i mean it's like uh so we see

533
00:23:16,870 --> 00:23:14,960
these images right and we can see that

534
00:23:18,710 --> 00:23:16,880
you know there's been an impact uh you

535
00:23:21,510 --> 00:23:18,720
know and since uh

536
00:23:22,230 --> 00:23:21,520
the orbiter was there the last time so

537
00:23:24,149 --> 00:23:22,240
you have like

538
00:23:25,669 --> 00:23:24,159

the problem is you have a time frame of

539
00:23:27,909 --> 00:23:25,679
you know

540
00:23:30,230 --> 00:23:27,919
anything from half to a full year and

541
00:23:33,110 --> 00:23:30,240
you have to go back and look at the data

542
00:23:34,390 --> 00:23:33,120
or you have to look through the data for

543
00:23:36,950 --> 00:23:34,400
that period

544
00:23:38,710 --> 00:23:36,960
and it's like literally like looking um

545
00:23:41,590 --> 00:23:38,720
for the needle in a haystack to

546
00:23:42,549 --> 00:23:41,600
to to find that thing but technically it

547
00:23:45,990 --> 00:23:42,559
could be in there

548
00:23:47,909 --> 00:23:46,000
says most of the meteorite impacts that

549
00:23:49,830 --> 00:23:47,919
we have seen on these images

550
00:23:52,230 --> 00:23:49,840
are relatively small as a result of

551
00:23:55,430 --> 00:23:52,240
which you are not expecting to see

552
00:23:57,990 --> 00:23:55,440
to pick them up by insight

553
00:23:59,430 --> 00:23:58,000
but they could be there and then i do

554
00:24:00,310 --> 00:23:59,440
actually have another question for you

555
00:24:03,750 --> 00:24:00,320
that's coming in

556
00:24:05,830 --> 00:24:03,760
cnc news on youtube asks what's the

557
00:24:08,470 --> 00:24:05,840
biggest surprise about the interior of

558
00:24:14,950 --> 00:24:11,590
that's for me that's for you

559
00:24:17,909 --> 00:24:14,960
oh thanks thanks raquel um

560
00:24:18,549 --> 00:24:17,919
the the biggest surprise i think i i

561
00:24:21,190 --> 00:24:18,559
sabine

562
00:24:22,870 --> 00:24:21,200
went over a little bit i think you know

563
00:24:24,230 --> 00:24:22,880

one of the things that i find the most

564
00:24:26,310 --> 00:24:24,240
surprising is this uh

565
00:24:28,230 --> 00:24:26,320
i mean we sort of had a good idea about

566
00:24:30,950 --> 00:24:28,240
you know the core of mars being

567
00:24:32,230 --> 00:24:30,960
being relatively big but we didn't

568
00:24:35,110 --> 00:24:32,240
expect it maybe to be

569
00:24:36,070 --> 00:24:35,120
so big as it is and as a result of the

570
00:24:37,750 --> 00:24:36,080
size

571
00:24:40,549 --> 00:24:37,760
you know the radius of of this thing

572
00:24:44,310 --> 00:24:40,559
being you know more than 1800 kilometers

573
00:24:46,549 --> 00:24:44,320
that the the the density that is that

574
00:24:47,510 --> 00:24:46,559
the total mass divided by the volume if

575
00:24:50,149 --> 00:24:47,520
you want

576
00:24:51,029 --> 00:24:50,159
is relatively low as sabine said and and

577
00:24:54,630 --> 00:24:51,039
you know as i

578
00:24:55,190 --> 00:24:54,640
uh pointed out in my um in my talk about

579
00:25:07,269 --> 00:24:55,200
the

580
00:25:08,070 --> 00:25:07,279
so that's i think for me is as

581
00:25:09,510 --> 00:25:08,080
personally

582
00:25:11,190 --> 00:25:09,520
you know is is one of the most

583
00:25:12,470 --> 00:25:11,200
intriguing things that we have to

584
00:25:14,230 --> 00:25:12,480
understand it's not

585
00:25:15,669 --> 00:25:14,240
something that's just going to be you

586
00:25:16,630 --> 00:25:15,679
know very simple and easy and

587
00:25:19,029 --> 00:25:16,640
straightforward to

588
00:25:20,870 --> 00:25:19,039

to come up with an answer to this thing

589
00:25:22,149 --> 00:25:20,880
but it does tell us something about the

590
00:25:24,789 --> 00:25:22,159
composition of ma

591
00:25:26,549 --> 00:25:24,799
of the core of mars which again tells us

592
00:25:29,110 --> 00:25:26,559
something about how moz

593
00:25:31,750 --> 00:25:29,120
formed particularly as to you know the

594
00:25:36,070 --> 00:25:31,760
timing it has had to have formed

595
00:25:37,750 --> 00:25:36,080
very early to have these light elements

596
00:25:40,390 --> 00:25:37,760
thanks samir and then sabine would you

597
00:25:42,149 --> 00:25:40,400
like to add to that

598
00:25:43,590 --> 00:25:42,159
i agree with amir completely to me that

599
00:25:44,870 --> 00:25:43,600
was very surprising and it's you know

600
00:25:46,470 --> 00:25:44,880
it's kind of funny because i'm

601
00:25:48,149 --> 00:25:46,480
i'm someone who studies how magnetic

602
00:25:50,149 --> 00:25:48,159
fields are generated and

603
00:25:51,750 --> 00:25:50,159
i really kind of wanted the core to be a

604
00:25:53,269 --> 00:25:51,760
little bit smaller and

605
00:25:54,789 --> 00:25:53,279
a little bit more dense because that

606
00:25:55,990 --> 00:25:54,799
actually makes it easier for the planet

607
00:25:57,990 --> 00:25:56,000
to generate a magnetic field

608
00:26:00,230 --> 00:25:58,000
early on so now that we know this

609
00:26:01,909 --> 00:26:00,240
information we have to kind of go back

610
00:26:03,269 --> 00:26:01,919
and revise what we thought about how

611
00:26:05,590 --> 00:26:03,279
mars dynamo could have

612
00:26:07,350 --> 00:26:05,600
worked and generated that field early on

613
00:26:09,029 --> 00:26:07,360

in its history so i find that very

614
00:26:11,190 --> 00:26:09,039
exciting

615
00:26:12,470 --> 00:26:11,200
okay we have lots of social media

616
00:26:15,110 --> 00:26:12,480
questions coming in

617
00:26:16,230 --> 00:26:15,120
another one is neil on youtube who asks

618
00:26:19,110 --> 00:26:16,240
will the geologic

619
00:26:22,470 --> 00:26:19,120
ages of mars need to be updated based on

620
00:26:26,149 --> 00:26:24,710
mark is thinking about that would you

621
00:26:29,029 --> 00:26:26,159
like to

622
00:26:30,390 --> 00:26:29,039
take a shot at the question i mean i

623
00:26:33,029 --> 00:26:30,400
think you know when you

624
00:26:35,430 --> 00:26:33,039
the the the remote observational

625
00:26:37,190 --> 00:26:35,440
geologists have have done a lot of uh

626
00:26:38,549 --> 00:26:37,200
really careful work with with crater

627
00:26:40,470 --> 00:26:38,559
accounting and all of that still

628
00:26:42,710 --> 00:26:40,480
applicable i don't think we've changed

629
00:26:44,230 --> 00:26:42,720
that story of what the surface of mars

630
00:26:44,950 --> 00:26:44,240
is doing that's that's all still the

631
00:26:48,070 --> 00:26:44,960
same

632
00:26:48,390 --> 00:26:48,080
um you know this as as amir have pointed

633
00:26:51,029 --> 00:26:48,400
out

634
00:26:52,149 --> 00:26:51,039
um this may have some impact in

635
00:26:54,789 --> 00:26:52,159
understanding what happened

636
00:26:55,430 --> 00:26:54,799
very early right in formation of mars

637
00:26:56,950 --> 00:26:55,440
but that's

638
00:26:59,190 --> 00:26:56,960

mainly not preserved on the surface

639
00:27:01,669 --> 00:26:59,200
because mars was molten then

640
00:27:02,390 --> 00:27:01,679
and so the the surface wasn't there yet

641
00:27:04,630 --> 00:27:02,400
um so

642
00:27:05,430 --> 00:27:04,640
uh yeah i don't think the geology

643
00:27:07,269 --> 00:27:05,440
picture

644
00:27:09,190 --> 00:27:07,279
has has changed they've done some

645
00:27:13,190 --> 00:27:09,200
amazing work with with what they can do

646
00:27:19,830 --> 00:27:16,710
great and then um

647
00:27:23,110 --> 00:27:19,840
partosh on youtube asks if there are no

648
00:27:24,389 --> 00:27:23,120
tectonic plates on mars how was olympus

649
00:27:27,990 --> 00:27:24,399
mons created and

650
00:27:34,549 --> 00:27:31,510
so i can start on that one so on earth

651
00:27:35,909 --> 00:27:34,559
yeah others might chime in um so

652
00:27:38,470 --> 00:27:35,919
the short answer is it's not fully

653
00:27:39,990 --> 00:27:38,480
understood right but what we do know is

654
00:27:40,870 --> 00:27:40,000
that on earth there are different kinds

655
00:27:44,149 --> 00:27:40,880
of volcanoes

656
00:27:45,750 --> 00:27:44,159
occur near subduction zones where one

657
00:27:46,870 --> 00:27:45,760
plate is going underneath another that

658
00:27:48,070 --> 00:27:46,880
melts some of the

659
00:27:49,830 --> 00:27:48,080
the crust underneath and creates

660
00:27:50,789 --> 00:27:49,840
volcanoes but we also have volcanoes

661
00:27:52,230 --> 00:27:50,799
kind of in the

662
00:27:54,630 --> 00:27:52,240
middle of plates and they're due to

663
00:27:56,310 --> 00:27:54,640

something called hot spots so a hot spot

664
00:27:57,190 --> 00:27:56,320
hawaii is a great example of a hotspot

665
00:27:58,789 --> 00:27:57,200
volcano

666
00:28:01,110 --> 00:27:58,799
so what happens on a hot spot is you

667
00:28:03,990 --> 00:28:01,120
have a plume of hot material

668
00:28:05,430 --> 00:28:04,000
coming through the mantle and that gets

669
00:28:08,149 --> 00:28:05,440
to the surface and eventually

670
00:28:10,549 --> 00:28:08,159
leads to volcanic activity now because

671
00:28:13,029 --> 00:28:10,559
mars is a one plate planet

672
00:28:14,870 --> 00:28:13,039
if it has a hot spot that hot spot would

673
00:28:16,710 --> 00:28:14,880
kind of stay in the same location

674
00:28:18,070 --> 00:28:16,720
under the surface which means that you

675
00:28:20,630 --> 00:28:18,080
can actually create much

676
00:28:22,230 --> 00:28:20,640
bigger volcanoes over it on earth

677
00:28:24,389 --> 00:28:22,240
because the plates are moving

678
00:28:25,510 --> 00:28:24,399
it's almost like your your your surface

679
00:28:27,350 --> 00:28:25,520
part of the volcano

680
00:28:28,789 --> 00:28:27,360
moves away from where the hot spot is

681
00:28:31,190 --> 00:28:28,799
and so you get a chain

682
00:28:33,269 --> 00:28:31,200
of volcanoes instead so it's thought

683
00:28:36,070 --> 00:28:33,279
that probably a region like tharsis

684
00:28:38,310 --> 00:28:36,080
got so big and so volcanic because a hot

685
00:28:40,070 --> 00:28:38,320
spot got to stay kind of under one spot

686
00:28:41,750 --> 00:28:40,080
for a long time

687
00:28:43,990 --> 00:28:41,760
i don't know if amir or mark want to add

688
00:28:45,909 --> 00:28:44,000

to that

689
00:28:47,750 --> 00:28:45,919
oh i think there's i would just add

690
00:28:50,470 --> 00:28:47,760
that's a really

691
00:28:51,350 --> 00:28:50,480
yeah it's absolutely correct but i i i'd

692
00:28:53,510 --> 00:28:51,360
add in that

693
00:28:55,430 --> 00:28:53,520
uh one of the interesting open questions

694
00:28:57,990 --> 00:28:55,440
that we still don't understand

695
00:28:59,430 --> 00:28:58,000
is why a hot spot would stay there for

696
00:29:02,470 --> 00:28:59,440
billions of years

697
00:29:04,230 --> 00:29:02,480
um to create uh the the olympus

698
00:29:06,149 --> 00:29:04,240
olympus mons and the tharsis uh

699
00:29:07,830 --> 00:29:06,159
volcanoes that that seem like they've

700
00:29:10,070 --> 00:29:07,840
been active pretty much over the entire

701
00:29:11,909 --> 00:29:10,080
history of mars it's recorded

702
00:29:14,310 --> 00:29:11,919
so that's that's something that we'd all

703
00:29:15,990 --> 00:29:14,320
still like to understand

704
00:29:18,549 --> 00:29:16,000
thank you that was a great question that

705
00:29:20,070 --> 00:29:18,559
came in okay okay go ahead

706
00:29:22,310 --> 00:29:20,080
i could just maybe add that you know

707
00:29:24,789 --> 00:29:22,320
there's been ideas that

708
00:29:26,710 --> 00:29:24,799
the the you know this this plume that

709
00:29:28,389 --> 00:29:26,720
sabine was talking about has been fed by

710
00:29:30,389 --> 00:29:28,399
the lower mantle

711
00:29:31,909 --> 00:29:30,399
like on earth we have plumes that you

712
00:29:34,549 --> 00:29:31,919
know originate from

713
00:29:36,149 --> 00:29:34,559

from deep down almost at the cormental

714
00:29:38,549 --> 00:29:36,159
boundary of the earth

715
00:29:39,510 --> 00:29:38,559
and that was sort of has been taken over

716
00:29:42,230 --> 00:29:39,520
and

717
00:29:43,750 --> 00:29:42,240
has been one of the main ideas but

718
00:29:45,029 --> 00:29:43,760
actually what's happened now because of

719
00:29:47,510 --> 00:29:45,039
the new results of insight

720
00:29:48,789 --> 00:29:47,520
is that mars doesn't have a lower mantle

721
00:29:50,630 --> 00:29:48,799
it doesn't have the equivalent of the

722
00:29:54,149 --> 00:29:50,640
lower mantle of the earth

723
00:29:56,789 --> 00:29:54,159
so you know that idea has to be

724
00:29:59,029 --> 00:29:56,799
you know it doesn't work and which is

725
00:29:59,750 --> 00:29:59,039
like sabine was saying we need to go

726
00:30:04,070 --> 00:29:59,760
back and

727
00:30:07,350 --> 00:30:06,070
we also have a question coming in about

728
00:30:09,909 --> 00:30:07,360
the crust uh

729
00:30:11,350 --> 00:30:09,919
kim on facebook asks do we know what

730
00:30:15,029 --> 00:30:11,360
causes the cracking

731
00:30:17,909 --> 00:30:15,039
of the crust uh

732
00:30:18,789 --> 00:30:17,919
yeah so i'm gonna do that yeah i can

733
00:30:21,909 --> 00:30:18,799
talk a little bit

734
00:30:23,430 --> 00:30:21,919
i so i you know even if you don't have

735
00:30:25,669 --> 00:30:23,440
plate tectonics

736
00:30:27,110 --> 00:30:25,679
planets still have tectonics in the

737
00:30:29,750 --> 00:30:27,120
sense of of their

738
00:30:30,870 --> 00:30:29,760

they are they they crack and deform as

739
00:30:34,230 --> 00:30:30,880
things happen

740
00:30:36,070 --> 00:30:34,240
um and so um there are some really long

741
00:30:37,430 --> 00:30:36,080
slow processes that are happening so it

742
00:30:40,070 --> 00:30:37,440
turns out um

743
00:30:40,870 --> 00:30:40,080
you know most of what planets do you can

744
00:30:43,430 --> 00:30:40,880
think about

745
00:30:44,789 --> 00:30:43,440
uh understanding it by what heat in the

746
00:30:47,990 --> 00:30:44,799
planet is doing

747
00:30:50,149 --> 00:30:48,000
um and so on on mars

748
00:30:51,350 --> 00:30:50,159
like every planet it's constantly losing

749
00:30:53,909 --> 00:30:51,360
heat out to the

750
00:30:55,990 --> 00:30:53,919
you know out to space um and that means

751
00:30:57,430 --> 00:30:56,000
it's slowly cooling down over time

752
00:31:00,070 --> 00:30:57,440
and when you cool things down they

753
00:31:02,950 --> 00:31:00,080
actually shrink um and that causes

754
00:31:04,950 --> 00:31:02,960
a long slow buildup of pressure because

755
00:31:07,590 --> 00:31:04,960
it's shrinking and that causes cracking

756
00:31:09,110 --> 00:31:07,600
and then also you've got these hot spots

757
00:31:09,990 --> 00:31:09,120
underneath that are causing great big

758
00:31:12,630 --> 00:31:10,000
volcanoes

759
00:31:14,149 --> 00:31:12,640
those are great big huge masses of rocks

760
00:31:16,470 --> 00:31:14,159
sitting on top of the crust

761
00:31:17,669 --> 00:31:16,480
that push down on the crust and cause

762
00:31:20,230 --> 00:31:17,679
all sorts of

763
00:31:21,350 --> 00:31:20,240

gravitational things at long distances

764
00:31:24,230 --> 00:31:21,360
away from

765
00:31:25,029 --> 00:31:24,240
big mountains like olympus mons and

766
00:31:26,950 --> 00:31:25,039
tarsus

767
00:31:28,070 --> 00:31:26,960
and so you know there are still all

768
00:31:30,230 --> 00:31:28,080
these forces

769
00:31:31,509 --> 00:31:30,240
that are happening um even though we

770
00:31:32,950 --> 00:31:31,519
don't have this

771
00:31:34,549 --> 00:31:32,960
pretty plate tectonics where

772
00:31:37,029 --> 00:31:34,559
everything's lining up in nice

773
00:31:37,830 --> 00:31:37,039
boundaries um there's still tectonics

774
00:31:39,909 --> 00:31:37,840
happening

775
00:31:41,509 --> 00:31:39,919
because of the processes that are

776
00:31:44,789 --> 00:31:41,519
happening as mars is getting rid of its

777
00:31:47,830 --> 00:31:46,470
thanks mark we have a lot of questions

778
00:31:50,149 --> 00:31:47,840
like i said coming in

779
00:31:50,870 --> 00:31:50,159
so now we have lofty on facebook who

780
00:31:53,830 --> 00:31:50,880
asks

781
00:31:55,190 --> 00:31:53,840
has the data given you clearly defined

782
00:31:59,190 --> 00:31:55,200
boundaries

783
00:32:01,750 --> 00:31:59,200
sizes to the crust mantle and core

784
00:32:04,470 --> 00:32:01,760
uh you know mark amir who would like to

785
00:32:07,669 --> 00:32:07,110
yeah i i i can take a first step but and

786
00:32:10,870 --> 00:32:07,679
then

787
00:32:12,950 --> 00:32:10,880
maybe uh mark can um follow up

788
00:32:13,990 --> 00:32:12,960

so yeah i mean we got some pretty good

789
00:32:17,029 --> 00:32:14,000
numbers uh

790
00:32:19,029 --> 00:32:17,039
off of say the crustal thickness but

791
00:32:20,630 --> 00:32:19,039
again it's beneath inside it's at one

792
00:32:23,110 --> 00:32:20,640
single location

793
00:32:25,110 --> 00:32:23,120
of course you can make inferences about

794
00:32:26,630 --> 00:32:25,120
locations elsewhere but you have to make

795
00:32:28,950 --> 00:32:26,640
certain assumptions

796
00:32:31,029 --> 00:32:28,960
but we do i mean we got some pretty good

797
00:32:33,269 --> 00:32:31,039
numbers now that allow us to really

798
00:32:34,710 --> 00:32:33,279
uh you know crustal thickness is

799
00:32:37,029 --> 00:32:34,720
constrained to within

800
00:32:38,310 --> 00:32:37,039
20 kilometers depending on certain

801
00:32:41,190 --> 00:32:38,320
assumptions

802
00:32:42,870 --> 00:32:41,200
and we know to good uh you know the core

803
00:32:45,909 --> 00:32:42,880
the size of the core as we said

804
00:32:46,389 --> 00:32:45,919
is is pretty well resolved to you know

805
00:32:50,470 --> 00:32:46,399
40

806
00:32:52,870 --> 00:32:50,480
the thickness of the mantle

807
00:32:54,950 --> 00:32:52,880
and we all you know we have we've we

808
00:32:58,310 --> 00:32:54,960
know the properties of the different

809
00:33:00,710 --> 00:32:58,320
you know the properties this the the

810
00:33:02,230 --> 00:33:00,720
the waves you know the the the speed

811
00:33:03,190 --> 00:33:02,240
with which the waves travel through

812
00:33:05,750 --> 00:33:03,200
these different

813
00:33:07,190 --> 00:33:05,760

regions across mapline core to a

814
00:33:10,310 --> 00:33:07,200
reasonable extent now

815
00:33:14,549 --> 00:33:10,320
and that's as we said before is what we

816
00:33:17,669 --> 00:33:16,630
yeah and you know and to be even more

817
00:33:21,190 --> 00:33:17,679
specific

818
00:33:24,070 --> 00:33:21,200
the you know we now can say um

819
00:33:25,350 --> 00:33:24,080
the the the core has a radius of one

820
00:33:26,789 --> 00:33:25,360
thousand eight hundred and thirty

821
00:33:27,590 --> 00:33:26,799
kilometers plus or minus forty

822
00:33:30,070 --> 00:33:27,600
kilometers

823
00:33:31,590 --> 00:33:30,080
we put specific numbers and the crust is

824
00:33:33,590 --> 00:33:31,600
a little bit more difficult because it

825
00:33:35,669 --> 00:33:33,600
varies from place to place but

826
00:33:37,269 --> 00:33:35,679
by comparing with gravity we can make an

827
00:33:39,190 --> 00:33:37,279
estimate of the range

828
00:33:40,470 --> 00:33:39,200
of possible average crustal thickness

829
00:33:43,830 --> 00:33:40,480
and it's i believe

830
00:33:46,230 --> 00:33:43,840
36 to 72 kilometers i think was what

831
00:33:47,590 --> 00:33:46,240
was what we said um and the interesting

832
00:33:49,269 --> 00:33:47,600
thing about both of those is how they

833
00:33:50,789 --> 00:33:49,279
compare with expectations we repeated

834
00:33:53,430 --> 00:33:50,799
over and over again that the core

835
00:33:55,750 --> 00:33:53,440
is at the big end of what we expected um

836
00:33:57,509 --> 00:33:55,760
the crust actually uh tends towards the

837
00:33:59,430 --> 00:33:57,519
the thinner end of the pre-mission

838
00:34:01,029 --> 00:33:59,440

expectations and excluded

839
00:34:03,269 --> 00:34:01,039
some models that suggested that the

840
00:34:05,990 --> 00:34:03,279
crush would be over 100 kilometers thick

841
00:34:06,710 --> 00:34:06,000
which also implied a really dense crust

842
00:34:10,389 --> 00:34:06,720
that uh

843
00:34:12,790 --> 00:34:10,399
matched uh the estimations of surface

844
00:34:13,669 --> 00:34:12,800
chemistry and then you extrapolate that

845
00:34:16,149 --> 00:34:13,679
down you get the

846
00:34:17,430 --> 00:34:16,159
how dense the whole crust is um because

847
00:34:18,790 --> 00:34:17,440
it's on the thin end we know that the

848
00:34:20,710 --> 00:34:18,800
crust is actually den

849
00:34:22,310 --> 00:34:20,720
is less dense than you'd get just from

850
00:34:23,829 --> 00:34:22,320
looking at the surface material so you

851
00:34:25,349 --> 00:34:23,839
probably have to have

852
00:34:27,589 --> 00:34:25,359
quite a bit of things like broken up

853
00:34:28,470 --> 00:34:27,599
porosity um in the top several

854
00:34:30,950 --> 00:34:28,480
kilometers of

855
00:34:32,230 --> 00:34:30,960
of the martian crust um and so you know

856
00:34:34,389 --> 00:34:32,240
the the

857
00:34:36,790 --> 00:34:34,399
the new knowledge we have compared with

858
00:34:37,829 --> 00:34:36,800
our pre-mission expectations are telling

859
00:34:41,510 --> 00:34:37,839
us new things about

860
00:34:43,430 --> 00:34:41,520
how what's happening with mars

861
00:34:45,669 --> 00:34:43,440
and we have several questions coming in

862
00:34:48,710 --> 00:34:45,679
about quakes uh

863
00:34:49,909 --> 00:34:48,720

novotassi on twitter asks um what power

864
00:34:53,109 --> 00:34:49,919
does quicks have

865
00:34:57,030 --> 00:34:53,119
would a person be able to hear or

866
00:35:01,190 --> 00:34:58,470
mark would you like to start and we'll

867
00:35:04,150 --> 00:35:01,200
give everything else so

868
00:35:04,870 --> 00:35:04,160
as a as a quick answer um if you were

869
00:35:08,630 --> 00:35:04,880
standing

870
00:35:10,790 --> 00:35:08,640
right next to insight you know uh on on

871
00:35:12,710 --> 00:35:10,800
at the lander um you wouldn't feel any

872
00:35:13,510 --> 00:35:12,720
of these these are really tiny motions

873
00:35:14,950 --> 00:35:13,520
that we're seeing

874
00:35:16,870 --> 00:35:14,960
so you wouldn't have felt a thing you

875
00:35:18,790 --> 00:35:16,880
wouldn't have heard a thing it it

876
00:35:20,710 --> 00:35:18,800
you you know you would have to look at

877
00:35:22,390 --> 00:35:20,720
the seismometer to know what it happened

878
00:35:24,310 --> 00:35:22,400
but you know the biggest events

879
00:35:27,270 --> 00:35:24,320
magnitude 3.8 ish

880
00:35:28,230 --> 00:35:27,280
um if you were right there at cerberus

881
00:35:29,670 --> 00:35:28,240
fossey where we

882
00:35:32,310 --> 00:35:29,680
where we think these events have

883
00:35:33,430 --> 00:35:32,320
happened um you'd probably feel it

884
00:35:34,870 --> 00:35:33,440
that's you know that's a

885
00:35:36,950 --> 00:35:34,880
that's a decent sized quake so if you

886
00:35:39,109 --> 00:35:36,960
were right there um where the quake

887
00:35:43,670 --> 00:35:39,119
happened yes but uh at the location of

888
00:35:47,910 --> 00:35:45,030

anyone else want to chime in before i

889
00:35:50,069 --> 00:35:47,920
get to the next question

890
00:35:51,030 --> 00:35:50,079
all right we have jason redd on twitter

891
00:35:53,910 --> 00:35:51,040
who asks

892
00:35:54,550 --> 00:35:53,920
why does mars have such a weak magnetic

893
00:35:56,950 --> 00:35:54,560
field

894
00:35:59,270 --> 00:35:56,960
even with a molten core would you like

895
00:36:01,990 --> 00:35:59,280
to start savina

896
00:36:04,390 --> 00:36:02,000
sure yeah i love that question so today

897
00:36:07,430 --> 00:36:04,400
mars does not have a dynamo the dynamo

898
00:36:09,030 --> 00:36:07,440
shut down very early in mars history

899
00:36:11,510 --> 00:36:09,040
and that's expected because you kind of

900
00:36:13,829 --> 00:36:11,520
need a planet needs to be able to cool

901
00:36:15,589 --> 00:36:13,839
very quickly in order to generate a

902
00:36:17,750 --> 00:36:15,599
dynamo in order to create motions in the

903
00:36:19,430 --> 00:36:17,760
core these churning motions that can

904
00:36:21,030 --> 00:36:19,440
bend and twist magnetic field lines and

905
00:36:23,270 --> 00:36:21,040
create new ones so

906
00:36:25,109 --> 00:36:23,280
mars is a smaller planet and now that we

907
00:36:26,470 --> 00:36:25,119
know information about the composition

908
00:36:28,550 --> 00:36:26,480
we also learned that it you know it

909
00:36:28,790 --> 00:36:28,560
can't really cool as quickly as it needs

910
00:36:34,390 --> 00:36:28,800
to

911
00:36:36,069 --> 00:36:34,400
there was a dynamo very early on early

912
00:36:37,589 --> 00:36:36,079
on in the history the planet could cool

913
00:36:40,630 --> 00:36:37,599

faster

914
00:36:42,470 --> 00:36:40,640
and there are remnants of that dynamo

915
00:36:44,470 --> 00:36:42,480
kind of frozen into rocks in the crust

916
00:36:47,109 --> 00:36:44,480
of the planet now those

917
00:36:48,310 --> 00:36:47,119
crustal magnetic signatures are actually

918
00:36:51,349 --> 00:36:48,320
we can measure them today

919
00:36:52,470 --> 00:36:51,359
so uh that's what we say that's what we

920
00:36:53,990 --> 00:36:52,480
see today when we talk about the

921
00:36:56,069 --> 00:36:54,000
magnetic field of mars today

922
00:36:57,910 --> 00:36:56,079
it's the rocks the magnetic fields from

923
00:36:58,710 --> 00:36:57,920
those rocks that froze in the magnetic

924
00:37:00,870 --> 00:36:58,720
field of mars

925
00:37:02,390 --> 00:37:00,880
so there are still weak fields and by

926
00:37:04,150 --> 00:37:02,400
week we mean compared to say

927
00:37:06,470 --> 00:37:04,160
the field strength at the surface of the

928
00:37:06,950 --> 00:37:06,480
earth today right earth has a dynamo

929
00:37:08,470 --> 00:37:06,960
earth

930
00:37:10,310 --> 00:37:08,480
today and it's creating an active

931
00:37:11,030 --> 00:37:10,320
magnetic field so that field is much

932
00:37:12,710 --> 00:37:11,040
stronger

933
00:37:16,550 --> 00:37:12,720
mars's is weaker because there's no

934
00:37:20,630 --> 00:37:18,310
and we actually have some questions

935
00:37:24,390 --> 00:37:20,640
coming in about

936
00:37:26,310 --> 00:37:24,400
your backgrounds uh we want to know

937
00:37:27,510 --> 00:37:26,320
how did you get your career nightman on

938
00:37:29,670 --> 00:37:27,520

youtube is asking

939
00:37:32,069 --> 00:37:29,680
how did you start your career and how

940
00:37:34,550 --> 00:37:32,079
did you get into analyzing quakes

941
00:37:36,230 --> 00:37:34,560
on another planet so i'll give everyone

942
00:37:38,310 --> 00:37:36,240
a chance to answer

943
00:37:40,950 --> 00:37:38,320
we can start with amir sabina and then

944
00:37:45,109 --> 00:37:43,829
okay i i i mean i studied geophysics and

945
00:37:47,990 --> 00:37:45,119
actually for my

946
00:37:48,790 --> 00:37:48,000
as part of my phd thesis i happened to

947
00:37:51,510 --> 00:37:48,800
study

948
00:37:52,069 --> 00:37:51,520
the quakes from the moon so that's how

949
00:37:55,030 --> 00:37:52,079
i'm i

950
00:37:56,069 --> 00:37:55,040
i did not start by i have a physics

951
00:37:57,910 --> 00:37:56,079
background and i

952
00:37:59,670 --> 00:37:57,920
came into this field of geophysics a

953
00:38:01,750 --> 00:37:59,680
little by happenstance

954
00:38:04,069 --> 00:38:01,760
and uh the first thing i was confronted

955
00:38:07,270 --> 00:38:04,079
with were these very strange luna

956
00:38:09,349 --> 00:38:07,280
are you know quakes from from the moon

957
00:38:12,230 --> 00:38:09,359
which are extremely noisy

958
00:38:13,349 --> 00:38:12,240
if you the the the data from mars uh the

959
00:38:15,270 --> 00:38:13,359
seismic data for mars

960
00:38:16,630 --> 00:38:15,280
really uh you know contain a lot more

961
00:38:18,230 --> 00:38:16,640
information than the

962
00:38:20,470 --> 00:38:18,240
than the quakes from the moon so that

963
00:38:26,710 --> 00:38:20,480

that was my take to into

964
00:38:30,630 --> 00:38:29,510
yeah so for me um my background is also

965
00:38:31,910 --> 00:38:30,640
in physics also

966
00:38:33,430 --> 00:38:31,920
in astronomy that's what i did in my

967
00:38:34,150 --> 00:38:33,440
undergrad and i really got interested in

968
00:38:36,069 --> 00:38:34,160
planets

969
00:38:37,190 --> 00:38:36,079
probably from watching star trek as a

970
00:38:39,190 --> 00:38:37,200
kid to be honest

971
00:38:40,870 --> 00:38:39,200
next generation that was sort of my my

972
00:38:42,230 --> 00:38:40,880
big inspiration

973
00:38:43,990 --> 00:38:42,240
but because i'm someone who studies

974
00:38:45,670 --> 00:38:44,000
magnetic fields i'm interested in kind

975
00:38:46,230 --> 00:38:45,680
of all the planets that have magnetic

976
00:38:47,990 --> 00:38:46,240
fields

977
00:38:50,150 --> 00:38:48,000
and mars is a really interesting

978
00:38:52,230 --> 00:38:50,160
magnetic planet so i love spending time

979
00:38:53,190 --> 00:38:52,240
uh thinking about mars and the insight

980
00:38:55,430 --> 00:38:53,200
mission was really

981
00:38:56,310 --> 00:38:55,440
a great opportunity for me to get to

982
00:38:58,150 --> 00:38:56,320
work with a

983
00:38:59,430 --> 00:38:58,160
group of scientists who have so many

984
00:39:01,270 --> 00:38:59,440
different expertise

985
00:39:02,630 --> 00:39:01,280
in studying the interior of a planet

986
00:39:04,150 --> 00:39:02,640
which is really kind of what

987
00:39:05,990 --> 00:39:04,160
what i love to do is trying to figure

988
00:39:07,109 --> 00:39:06,000

out what's going on way deep down inside

989
00:39:12,870 --> 00:39:07,119
the planet

990
00:39:16,069 --> 00:39:15,349
yeah so i started um uh unlike the other

991
00:39:18,470 --> 00:39:16,079
two my

992
00:39:21,190 --> 00:39:18,480
initial background was actually geology

993
00:39:21,990 --> 00:39:21,200
um uh and uh i started in geology but i

994
00:39:24,790 --> 00:39:22,000
was also

995
00:39:26,310 --> 00:39:24,800
you know kind of good at math so so i

996
00:39:28,470 --> 00:39:26,320
had so i

997
00:39:30,550 --> 00:39:28,480
wandered off into seismology and when i

998
00:39:31,670 --> 00:39:30,560
uh did my phd i mainly focused on the

999
00:39:32,870 --> 00:39:31,680
earth i was looking at

1000
00:39:34,790 --> 00:39:32,880
understanding what's happening in the

1001
00:39:37,190 --> 00:39:34,800
earth's mantle

1002
00:39:39,349 --> 00:39:37,200
but right after finishing my degree i

1003
00:39:40,550 --> 00:39:39,359
stumbled on some funding that was to

1004
00:39:42,390 --> 00:39:40,560
make up

1005
00:39:44,630 --> 00:39:42,400
what seismology might look like on

1006
00:39:47,750 --> 00:39:44,640
europa which is a moon of jupiter

1007
00:39:49,430 --> 00:39:47,760
um and uh it was you know it was

1008
00:39:52,150 --> 00:39:49,440
funded through a mission that never flew

1009
00:39:54,390 --> 00:39:52,160
but i got a chance to think about what

1010
00:39:55,270 --> 00:39:54,400
seismograms on another planet might look

1011
00:39:57,109 --> 00:39:55,280
like and it's

1012
00:39:58,950 --> 00:39:57,119
been something i've constantly kept

1013
00:40:01,030 --> 00:39:58,960

working on and eventually uh

1014
00:40:02,710 --> 00:40:01,040
four years ago i i moved to jpl and

1015
00:40:05,670 --> 00:40:02,720
that's all i think about now is

1016
00:40:07,190 --> 00:40:05,680
is uh thinking about seismology on other

1017
00:40:10,390 --> 00:40:07,200
planets and that's mars

1018
00:40:12,069 --> 00:40:10,400
that's um the moon that's europa

1019
00:40:13,670 --> 00:40:12,079
titan the moon of saturn all of these

1020
00:40:15,990 --> 00:40:13,680
things i love to think about

1021
00:40:17,430 --> 00:40:16,000
uh what quakes look like there and how

1022
00:40:19,589 --> 00:40:17,440
they look different than what we see on

1023
00:40:20,950 --> 00:40:19,599
earth

1024
00:40:22,710 --> 00:40:20,960
it's great to hear all your different

1025
00:40:24,390 --> 00:40:22,720
career paths to get here

1026
00:40:25,750 --> 00:40:24,400
and i actually have another question for

1027
00:40:30,309 --> 00:40:25,760
you mark

1028
00:40:33,190 --> 00:40:30,319
we have um samuel on linkedin who asks

1029
00:40:34,950 --> 00:40:33,200
can you estimate how old the quakes are

1030
00:40:38,710 --> 00:40:34,960
and if more might happen

1031
00:40:40,309 --> 00:40:38,720
in the near future

1032
00:40:42,390 --> 00:40:40,319
well um i mean i'm not sure what you

1033
00:40:43,589 --> 00:40:42,400
mean by how old so the quakes

1034
00:40:45,670 --> 00:40:43,599
all the quakes we're seeing are things

1035
00:40:46,069 --> 00:40:45,680
that are happening right now um so this

1036
00:40:48,630 --> 00:40:46,079
is

1037
00:40:50,150 --> 00:40:48,640
uh you know we i i think sometimes

1038
00:40:51,270 --> 00:40:50,160

people think of mars as old

1039
00:40:53,430 --> 00:40:51,280
you know when you look at the surface of

1040
00:40:55,990 --> 00:40:53,440
mars everything is billions of years old

1041
00:40:57,750 --> 00:40:56,000
or millions of years old um and so

1042
00:40:59,030 --> 00:40:57,760
you think of it as old but you know what

1043
00:41:00,550 --> 00:40:59,040
we're seeing right now is activity

1044
00:41:02,390 --> 00:41:00,560
that's happening right now

1045
00:41:04,829 --> 00:41:02,400
um this is stuff that's happening

1046
00:41:06,150 --> 00:41:04,839
primarily under an area that we know had

1047
00:41:09,190 --> 00:41:06,160
volcanism

1048
00:41:12,309 --> 00:41:09,200
in the past million years or so

1049
00:41:13,829 --> 00:41:12,319
um not we don't know exactly but uh

1050
00:41:15,510 --> 00:41:13,839
but that means that there's activity

1051
00:41:15,910 --> 00:41:15,520
happening there right now so we're

1052
00:41:17,510 --> 00:41:15,920
seeing

1053
00:41:22,470 --> 00:41:17,520
quakes that are happening right now and

1054
00:41:25,829 --> 00:41:25,430
let me pull it back up could we detect

1055
00:41:30,550 --> 00:41:25,839
more

1056
00:41:32,069 --> 00:41:30,560
happen in the near future can we predict

1057
00:41:33,829 --> 00:41:32,079
it

1058
00:41:35,670 --> 00:41:33,839
yeah so you know we can look at the

1059
00:41:37,750 --> 00:41:35,680
statistics of what's already happened

1060
00:41:40,069 --> 00:41:37,760
um and so we've seen lots of quakes um

1061
00:41:42,230 --> 00:41:40,079
more than 700 quakes have been observed

1062
00:41:43,430 --> 00:41:42,240
already and so we're going to keep

1063
00:41:44,470 --> 00:41:43,440

seeing those those are

1064
00:41:46,069 --> 00:41:44,480
happening we're actually in a really

1065
00:41:47,910 --> 00:41:46,079
good time to listen right now because

1066
00:41:48,870 --> 00:41:47,920
mars atmosphere is really quiet during

1067
00:41:51,030 --> 00:41:48,880
this time of year

1068
00:41:52,630 --> 00:41:51,040
and so we can we can detect a lot of

1069
00:41:53,510 --> 00:41:52,640
quakes and so we're detecting them every

1070
00:41:56,309 --> 00:41:53,520
day

1071
00:41:57,670 --> 00:41:56,319
um as far as what kinds we're going to

1072
00:41:59,030 --> 00:41:57,680
see we'll probably see a lot that are

1073
00:41:59,910 --> 00:41:59,040
pretty similar to what we've already

1074
00:42:01,510 --> 00:41:59,920
seen

1075
00:42:03,109 --> 00:42:01,520
but if you look at the statistics it's

1076
00:42:05,510 --> 00:42:03,119
possible we'll see some bigger

1077
00:42:06,710 --> 00:42:05,520
events where you know fingers crossed we

1078
00:42:09,910 --> 00:42:06,720
would love to see

1079
00:42:13,109 --> 00:42:12,150
and we have a follow-up question for

1080
00:42:18,470 --> 00:42:13,119
amir

1081
00:42:20,550 --> 00:42:18,480
in a little bit more detail why the

1082
00:42:26,069 --> 00:42:20,560
light elements in the core suggest

1083
00:42:30,630 --> 00:42:27,670
well that has something to do with the

1084
00:42:31,109 --> 00:42:30,640
fact that you got to um you know when

1085
00:42:33,349 --> 00:42:31,119
mars

1086
00:42:34,630 --> 00:42:33,359
form due to clumping together of

1087
00:42:36,790 --> 00:42:34,640
material

1088
00:42:38,390 --> 00:42:36,800

you have to ensure that you know you get

1089
00:42:41,349 --> 00:42:38,400
a lot of these light elements

1090
00:42:43,430 --> 00:42:41,359
into your you know into uh into the

1091
00:42:45,990 --> 00:42:43,440
planet accumulated or treated into the

1092
00:42:51,589 --> 00:42:49,030
which is for for for

1093
00:42:52,630 --> 00:42:51,599
for mars you know the constraint is

1094
00:42:56,390 --> 00:42:52,640
really

1095
00:42:59,109 --> 00:42:56,400
how do you get into such a little planet

1096
00:43:00,870 --> 00:42:59,119
at the location where it's at how can

1097
00:43:03,589 --> 00:43:00,880
you really um

1098
00:43:04,870 --> 00:43:03,599
how can we really explain i mean we have

1099
00:43:06,790 --> 00:43:04,880
to be careful because of course

1100
00:43:09,510 --> 00:43:06,800
earth also the earth's core also

1101
00:43:11,430 --> 00:43:09,520
contains you know light elements

1102
00:43:12,710 --> 00:43:11,440
but they are slightly different light

1103
00:43:15,270 --> 00:43:12,720
elements than than

1104
00:43:17,829 --> 00:43:15,280
those from oz and you know the problem

1105
00:43:20,950 --> 00:43:17,839
is again this this number this mean core

1106
00:43:23,670 --> 00:43:20,960
density that we're getting at is so low

1107
00:43:25,750 --> 00:43:23,680
or is relatively low that you need a lot

1108
00:43:26,069 --> 00:43:25,760
of these extremely light elements such

1109
00:43:29,190 --> 00:43:26,079
as

1110
00:43:31,510 --> 00:43:29,200
carbon oxygen and particularly hydrogen

1111
00:43:34,069 --> 00:43:31,520
and those elements you know that they

1112
00:43:36,630 --> 00:43:34,079
they only stick around the solar nebula

1113
00:43:38,870 --> 00:43:36,640

um you know very early at the very

1114
00:43:40,710 --> 00:43:38,880
earliest stages of

1115
00:43:42,550 --> 00:43:40,720
you know planetary formation in the in

1116
00:43:44,550 --> 00:43:42,560
the inner solar system

1117
00:43:45,750 --> 00:43:44,560
because after a couple million years

1118
00:43:48,630 --> 00:43:45,760
what happens is that the

1119
00:43:50,790 --> 00:43:48,640
the young sun gets very active and this

1120
00:43:53,030 --> 00:43:50,800
solar nebula is this gaseous

1121
00:43:55,510 --> 00:43:53,040
solar nebula this gaseous material gets

1122
00:43:57,270 --> 00:43:55,520
dispersed into the outer reaches of the

1123
00:43:59,190 --> 00:43:57,280
of the solar system right and then this

1124
00:44:00,390 --> 00:43:59,200
stuff is gone and when this stuff is

1125
00:44:02,950 --> 00:44:00,400
gone you're not gonna

1126
00:44:03,910 --> 00:44:02,960
you know you can't get it into uh i mean

1127
00:44:05,910 --> 00:44:03,920
let alone

1128
00:44:07,349 --> 00:44:05,920
on on the planet you're not gonna get it

1129
00:44:09,829 --> 00:44:07,359
into the core of the planet

1130
00:44:11,670 --> 00:44:09,839
right so that's why it has you know the

1131
00:44:14,630 --> 00:44:11,680
constraint that it has to have formed

1132
00:44:17,990 --> 00:44:15,910
and sabina do you have anything you'd

1133
00:44:20,630 --> 00:44:18,000
like to add to

1134
00:44:21,670 --> 00:44:20,640
no i mean i i thought that was that was

1135
00:44:24,069 --> 00:44:21,680
great it was a

1136
00:44:24,710 --> 00:44:24,079
great answer now we have a question

1137
00:44:28,150 --> 00:44:24,720
coming in

1138
00:44:31,990 --> 00:44:28,160

about the studies dan on twitter asks

1139
00:44:34,230 --> 00:44:32,000
finding say the crust of mars is

1140
00:44:36,230 --> 00:44:34,240
likely highly enriched in radioactive

1141
00:44:38,470 --> 00:44:36,240
elements that help to heat

1142
00:44:39,910 --> 00:44:38,480
this layer at the expense of the

1143
00:44:43,349 --> 00:44:39,920
interior

1144
00:44:46,870 --> 00:44:43,359
what radioactive elements are likely

1145
00:44:47,190 --> 00:44:46,880
how do you detect that and why are they

1146
00:44:57,349 --> 00:44:47,200
at

1147
00:45:03,270 --> 00:44:59,670
amir you want to talk about it or uh or

1148
00:45:05,670 --> 00:45:03,280
i i can talk about it too but

1149
00:45:07,109 --> 00:45:05,680
have a uh don't know in any case i would

1150
00:45:09,270 --> 00:45:07,119
have to have the question again please

1151
00:45:12,230 --> 00:45:09,280
raquel

1152
00:45:13,510 --> 00:45:12,240
yes of course um findings say the crust

1153
00:45:15,349 --> 00:45:13,520
of mars is high

1154
00:45:17,750 --> 00:45:15,359
likely highly enriched in radioactive

1155
00:45:19,270 --> 00:45:17,760
elements that help heat the

1156
00:45:21,990 --> 00:45:19,280
this layer at the expense of the

1157
00:45:22,790 --> 00:45:22,000
interior what radioactive elements are

1158
00:45:24,950 --> 00:45:22,800
likely

1159
00:45:25,990 --> 00:45:24,960
how do you detect that and why are they

1160
00:45:29,349 --> 00:45:26,000
at the expense of the

1161
00:45:31,910 --> 00:45:29,359
interior ah okay

1162
00:45:33,589 --> 00:45:31,920
yeah so the main radioactive elements we

1163
00:45:36,550 --> 00:45:33,599

have on the crust

1164
00:45:37,990 --> 00:45:36,560
would be uranium thorium and potassium

1165
00:45:40,390 --> 00:45:38,000
and that's the same on earth and pretty

1166
00:45:43,670 --> 00:45:40,400
much the same on all terrestrial planets

1167
00:45:47,750 --> 00:45:43,680
um we say that they are enriched

1168
00:45:49,430 --> 00:45:47,760
because we have you know prior to inside

1169
00:45:52,390 --> 00:45:49,440
landing on mars we

1170
00:45:54,309 --> 00:45:52,400
had this there was this previous in the

1171
00:45:56,630 --> 00:45:54,319
early 2000s this

1172
00:45:59,190 --> 00:45:56,640
mars global surveyor satellite mission

1173
00:46:00,950 --> 00:45:59,200
that was orbiting mars and was measuring

1174
00:46:02,950 --> 00:46:00,960
it contained a so-called gamma ray

1175
00:46:05,030 --> 00:46:02,960
spectrometer which measure

1176
00:46:06,069 --> 00:46:05,040
basically measures uh the number of

1177
00:46:07,829 --> 00:46:06,079
gamma rays

1178
00:46:09,670 --> 00:46:07,839
that are emitted from the surface and

1179
00:46:12,069 --> 00:46:09,680
gamma rays are emitted

1180
00:46:13,430 --> 00:46:12,079
from radioactive decay of these

1181
00:46:15,670 --> 00:46:13,440
radioactive elements

1182
00:46:17,349 --> 00:46:15,680
right so we prior to insight we had this

1183
00:46:20,150 --> 00:46:17,359
idea of of

1184
00:46:21,670 --> 00:46:20,160
the radioactive element content but of

1185
00:46:25,270 --> 00:46:21,680
course only on the surface

1186
00:46:28,069 --> 00:46:25,280
right and now what we did

1187
00:46:29,910 --> 00:46:28,079
with insight is of course to to you know

1188
00:46:31,430 --> 00:46:29,920

you look inside the planet you look

1189
00:46:34,470 --> 00:46:31,440
inside the crust

1190
00:46:37,030 --> 00:46:34,480
so the the i mean again i have we have

1191
00:46:40,710 --> 00:46:37,040
to be aware that insight doesn't

1192
00:46:42,710 --> 00:46:40,720
uh directly see you know radioactive

1193
00:46:43,910 --> 00:46:42,720
radioactive elements inside is all about

1194
00:46:46,630 --> 00:46:43,920
seismology

1195
00:46:47,990 --> 00:46:46,640
but you can indirectly estimate from the

1196
00:46:50,550 --> 00:46:48,000
seismic data

1197
00:46:51,829 --> 00:46:50,560
and from the models we produce by you

1198
00:46:55,670 --> 00:46:51,839
know running

1199
00:46:59,190 --> 00:46:55,680
so-called you know models that sort of

1200
00:47:00,790 --> 00:46:59,200
try to mimic the evolution of mars over

1201
00:47:03,109 --> 00:47:00,800
four and a half billion years

1202
00:47:05,670 --> 00:47:03,119
right and what you end up with when you

1203
00:47:07,109 --> 00:47:05,680
run these so-called evolution models

1204
00:47:09,510 --> 00:47:07,119
uh over four and a half billion years

1205
00:47:10,150 --> 00:47:09,520
you end up with something today which is

1206
00:47:12,150 --> 00:47:10,160
you know

1207
00:47:13,910 --> 00:47:12,160
the models will predict uh crustal

1208
00:47:16,150 --> 00:47:13,920
thickness it will predict a

1209
00:47:17,589 --> 00:47:16,160
lithospheric thickness and and it will

1210
00:47:19,109 --> 00:47:17,599
predict temperatures

1211
00:47:20,790 --> 00:47:19,119
and those things from these modeling

1212
00:47:23,109 --> 00:47:20,800
studies you can compare

1213
00:47:24,230 --> 00:47:23,119

with what we have predicted from insight

1214
00:47:27,030 --> 00:47:24,240
and when you do that

1215
00:47:28,630 --> 00:47:27,040
you find that you know in order to to

1216
00:47:30,069 --> 00:47:28,640
predict the crustal thickness that

1217
00:47:33,109 --> 00:47:30,079
inside a scene and the

1218
00:47:34,069 --> 00:47:33,119
lithospheric thickness uh the crust of

1219
00:47:35,990 --> 00:47:34,079
moss

1220
00:47:37,589 --> 00:47:36,000
needs to be enriched in these light

1221
00:47:38,710 --> 00:47:37,599
elements if not you don't get the right

1222
00:47:40,390 --> 00:47:38,720
you know crustal thickness and

1223
00:47:41,829 --> 00:47:40,400
lithospheric thickness and temperature

1224
00:47:44,790 --> 00:47:41,839
and stuff like that

1225
00:47:46,309 --> 00:47:44,800
so relative to what we had what we knew

1226
00:47:49,670 --> 00:47:46,319
you know from the surface from this

1227
00:47:51,510 --> 00:47:49,680
uh mass global severe the the radiation

1228
00:47:52,710 --> 00:47:51,520
radioactive elements have to be you know

1229
00:47:54,470 --> 00:47:52,720
they're more of them right

1230
00:47:55,910 --> 00:47:54,480
but that means you know you can't just

1231
00:47:57,510 --> 00:47:55,920
get rid of mgs because

1232
00:47:59,750 --> 00:47:57,520
mg has actually measured something on

1233
00:48:00,470 --> 00:47:59,760
the surface but it means that you know

1234
00:48:03,109 --> 00:48:00,480
as you

1235
00:48:04,150 --> 00:48:03,119
inside the crust you know deeper down in

1236
00:48:06,790 --> 00:48:04,160
the crust

1237
00:48:08,309 --> 00:48:06,800
you have rocks different type of rocks

1238
00:48:09,990 --> 00:48:08,319

on the surface that contain more

1239
00:48:15,109 --> 00:48:10,000
radioactive elements

1240
00:48:21,270 --> 00:48:19,190
yeah the key elements there is that

1241
00:48:22,390 --> 00:48:21,280
there's you know we have estimates of

1242
00:48:24,309 --> 00:48:22,400
how much

1243
00:48:25,510 --> 00:48:24,319
of the these heat producing elements

1244
00:48:28,950 --> 00:48:25,520
were available

1245
00:48:31,750 --> 00:48:28,960
to mars based on estimates of of of

1246
00:48:32,710 --> 00:48:31,760
the solar material that that that

1247
00:48:34,309 --> 00:48:32,720
created mars

1248
00:48:36,150 --> 00:48:34,319
and so if you're putting more in the

1249
00:48:37,190 --> 00:48:36,160
crust it means you're taking more out of

1250
00:48:38,950 --> 00:48:37,200
the mantle so this

1251
00:48:41,349 --> 00:48:38,960
you know when you melt the mantle to

1252
00:48:43,910 --> 00:48:41,359
create the crust i wouldn't you know um

1253
00:48:45,750 --> 00:48:43,920
you are shoving those heat producing

1254
00:48:48,150 --> 00:48:45,760
elements into the crust and therefore

1255
00:48:49,349 --> 00:48:48,160
relatively cooling down the mantle um

1256
00:48:50,950 --> 00:48:49,359
because you don't have as much heat

1257
00:48:54,069 --> 00:48:50,960
production in the mantle so

1258
00:48:55,670 --> 00:48:54,079
that makes the mantle a little more cool

1259
00:48:57,670 --> 00:48:55,680
gives you a thicker lithosphere all of

1260
00:49:06,470 --> 00:48:57,680
that because we're putting all of those

1261
00:49:09,829 --> 00:49:07,829
just to follow up to what mark said i

1262
00:49:13,109 --> 00:49:09,839
mean you know and and

1263
00:49:14,309 --> 00:49:13,119

the the real way to get at uh to get at

1264
00:49:17,670 --> 00:49:14,319
the the you know the

1265
00:49:19,190 --> 00:49:17,680
how many radioactive or the radioactive

1266
00:49:19,990 --> 00:49:19,200
element content of the crust would have

1267
00:49:21,750 --> 00:49:20,000
been to

1268
00:49:24,150 --> 00:49:21,760
you know put that heat flow probe on

1269
00:49:25,109 --> 00:49:24,160
there which we did but unfortunately it

1270
00:49:28,150 --> 00:49:25,119
never

1271
00:49:31,190 --> 00:49:28,160
you know reached the the the depths

1272
00:49:32,549 --> 00:49:31,200
that it had to in order to measure the

1273
00:49:35,510 --> 00:49:32,559
heat flow

1274
00:49:37,270 --> 00:49:35,520
uh that we would have needed in order to

1275
00:49:39,030 --> 00:49:37,280
to put constraints on the radiator

1276
00:49:41,589 --> 00:49:39,040
radioactive element content of the

1277
00:49:45,190 --> 00:49:41,599
martian crust and the heat flow and

1278
00:49:49,510 --> 00:49:45,200
you know everything beneath it really

1279
00:49:51,910 --> 00:49:49,520
so that was a very unfortunate um yeah

1280
00:49:54,150 --> 00:49:51,920
occurrence that it didn't function of

1281
00:49:59,430 --> 00:49:57,349
i'd like to thank you and mark for that

1282
00:50:01,990 --> 00:49:59,440
really detailed answer to the question

1283
00:50:02,790 --> 00:50:02,000
we are getting some great conversations

1284
00:50:05,270 --> 00:50:02,800
going and

1285
00:50:07,670 --> 00:50:05,280
we have neil's on youtube who is asking

1286
00:50:09,990 --> 00:50:07,680
are any of insight's findings

1287
00:50:11,190 --> 00:50:10,000
likely to influence the science mission

1288
00:50:16,870 --> 00:50:11,200

of perseverance

1289
00:50:20,069 --> 00:50:19,589
mark would you like to try yeah oh i

1290
00:50:23,510 --> 00:50:20,079
mean

1291
00:50:23,910 --> 00:50:23,520
so um you know so you know perseverance

1292
00:50:27,510 --> 00:50:23,920
is

1293
00:50:29,829 --> 00:50:27,520
know we're not

1294
00:50:31,430 --> 00:50:29,839
uh directly affecting that you know

1295
00:50:34,790 --> 00:50:31,440
we're

1296
00:50:35,670 --> 00:50:34,800
inside isn't at the surface so

1297
00:50:37,270 --> 00:50:35,680
perseverance

1298
00:50:38,870 --> 00:50:37,280
is going to make their decisions on what

1299
00:50:40,150 --> 00:50:38,880
to sample um on

1300
00:50:41,670 --> 00:50:40,160
the surface based on orbital

1301
00:50:42,790 --> 00:50:41,680
observations and what they see as they

1302
00:50:45,190 --> 00:50:42,800
drive around

1303
00:50:46,470 --> 00:50:45,200
um and so uh we're not gonna probably

1304
00:50:49,670 --> 00:50:46,480
have any direct impact

1305
00:50:52,790 --> 00:50:49,680
on on perseverance necessarily um

1306
00:50:54,870 --> 00:50:52,800
but um you know in terms of

1307
00:50:56,470 --> 00:50:54,880
future missions things we'd like to see

1308
00:50:58,710 --> 00:50:56,480
on mars i mean you know so

1309
00:51:01,190 --> 00:50:58,720
amir just pointed out we'd still love to

1310
00:51:03,910 --> 00:51:01,200
get a heat flow measurement um

1311
00:51:04,549 --> 00:51:03,920
that would be a great uh future mission

1312
00:51:07,109 --> 00:51:04,559
and

1313
00:51:07,670 --> 00:51:07,119

we now know more about where quakes

1314
00:51:10,230 --> 00:51:07,680
happen

1315
00:51:11,270 --> 00:51:10,240
uh near insight but as sabina said

1316
00:51:14,790 --> 00:51:11,280
there's also

1317
00:51:16,069 --> 00:51:14,800
uh likely to be seismicity associated

1318
00:51:17,990 --> 00:51:16,079
with narcissists so we can imagine

1319
00:51:18,950 --> 00:51:18,000
putting seismometers in different places

1320
00:51:21,030 --> 00:51:18,960
on the surface and

1321
00:51:21,990 --> 00:51:21,040
we're constraining better where we'd

1322
00:51:23,829 --> 00:51:22,000
like to do that in order

1323
00:51:26,230 --> 00:51:23,839
to better increase our understanding of

1324
00:51:30,069 --> 00:51:27,750
and if i can add just a little bit to

1325
00:51:32,470 --> 00:51:30,079
that even though you know the

1326
00:51:33,670 --> 00:51:32,480
a lot of the basis of the mission and

1327
00:51:35,109 --> 00:51:33,680
the focus of the mission is

1328
00:51:37,589 --> 00:51:35,119
the seismicity and understanding the

1329
00:51:39,270 --> 00:51:37,599
deep interior there are instruments on

1330
00:51:40,470 --> 00:51:39,280
insight that look at the surface and

1331
00:51:41,829 --> 00:51:40,480
look at the atmosphere so we have

1332
00:51:43,430 --> 00:51:41,839
cameras that can tell us about the

1333
00:51:45,030 --> 00:51:43,440
surface and that helps us understand the

1334
00:51:47,430 --> 00:51:45,040
geology and how things

1335
00:51:48,790 --> 00:51:47,440
what what's the very very top layer of

1336
00:51:51,030 --> 00:51:48,800
the surface what what's it

1337
00:51:55,670 --> 00:51:51,040
all about and even though we're learning

1338
00:51:59,349 --> 00:51:57,349

but it's an important data point to try

1339
00:52:01,589 --> 00:51:59,359
and understand all of mars

1340
00:52:02,950 --> 00:52:01,599
um and we learned about the aeromar

1341
00:52:04,950 --> 00:52:02,960
turns out to be important

1342
00:52:06,630 --> 00:52:04,960
to unders to kind of take out the

1343
00:52:09,430 --> 00:52:06,640
atmospheric signals from the um

1344
00:52:11,030 --> 00:52:09,440
seismicity signals and that again can

1345
00:52:13,270 --> 00:52:11,040
kind of be used with with

1346
00:52:15,030 --> 00:52:13,280
all the atmospheric information we have

1347
00:52:16,470 --> 00:52:15,040
on mars and all that's going to be

1348
00:52:22,069 --> 00:52:16,480
helpful for any mission

1349
00:52:25,670 --> 00:52:23,670
we do have time for a couple more

1350
00:52:28,230 --> 00:52:25,680
questions so we have

1351
00:52:30,069 --> 00:52:28,240
jesse on facebook who asks scientists

1352
00:52:32,069 --> 00:52:30,079
believed the factors like the moon's

1353
00:52:35,030 --> 00:52:32,079
gravitational push and pull

1354
00:52:35,589 --> 00:52:35,040
the planet compressing or meteor impacts

1355
00:52:38,069 --> 00:52:35,599
caused

1356
00:52:39,829 --> 00:52:38,079
quakes how likely is it that more than

1357
00:52:45,030 --> 00:52:39,839
one factor could be causing

1358
00:52:49,430 --> 00:52:47,670
uh quakes i mean i can i can talk about

1359
00:52:52,470 --> 00:52:49,440
talk about that briefly i mean

1360
00:52:55,910 --> 00:52:52,480
um quakes are are uh

1361
00:52:56,630 --> 00:52:55,920
uh an expression of stresses and forces

1362
00:53:00,069 --> 00:52:56,640
within a

1363
00:53:01,910 --> 00:53:00,079

within the crest to mars and undoubtedly

1364
00:53:03,589 --> 00:53:01,920
that those those stresses are the

1365
00:53:05,670 --> 00:53:03,599
combination of lots of different things

1366
00:53:08,230 --> 00:53:05,680
um you know i i i i

1367
00:53:09,349 --> 00:53:08,240
got at that earlier with talking about

1368
00:53:12,630 --> 00:53:09,359
the the overall

1369
00:53:13,670 --> 00:53:12,640
slow cooling and the the the weight of

1370
00:53:15,670 --> 00:53:13,680
big things

1371
00:53:17,349 --> 00:53:15,680
uh sitting on the surface of mars you

1372
00:53:19,829 --> 00:53:17,359
know and and you know that's even

1373
00:53:21,430 --> 00:53:19,839
including weight of uh the ice caps on

1374
00:53:23,589 --> 00:53:21,440
at the north and south pole all of those

1375
00:53:25,670 --> 00:53:23,599
things are putting

1376
00:53:27,589 --> 00:53:25,680
pressures on on mars and changing the

1377
00:53:30,230 --> 00:53:27,599
stress within the crust so everything

1378
00:53:30,710 --> 00:53:30,240
is a a is a combination there's there's

1379
00:53:33,910 --> 00:53:30,720
no

1380
00:53:34,549 --> 00:53:33,920
one single answer um to what's causing

1381
00:53:44,470 --> 00:53:34,559
the

1382
00:53:46,630 --> 00:53:44,480
which were

1383
00:53:48,309 --> 00:53:46,640
you know apparently uh they correlated

1384
00:53:50,790 --> 00:53:48,319
very well with the tides that were

1385
00:53:53,109 --> 00:53:50,800
raised on the moon by the earth

1386
00:53:54,390 --> 00:53:53,119
and uh you i suppose the question is a

1387
00:53:57,430 --> 00:53:54,400
little bit the same here

1388
00:54:00,549 --> 00:53:57,440

could uh you know the martian moons um

1389
00:54:02,630 --> 00:54:00,559
influence mars uh marsquake activity

1390
00:54:03,750 --> 00:54:02,640
but that's actually pretty simple to

1391
00:54:07,349 --> 00:54:03,760
answer and it's

1392
00:54:09,030 --> 00:54:07,359
i mean we uh i not me personally but

1393
00:54:11,190 --> 00:54:09,040
people have looked for you know

1394
00:54:11,589 --> 00:54:11,200
correlations between the tithes raised

1395
00:54:14,309 --> 00:54:11,599
by

1396
00:54:16,630 --> 00:54:14,319
folk i mean daimus is too far away and

1397
00:54:19,510 --> 00:54:16,640
it's too small to raise any significant

1398
00:54:20,470 --> 00:54:19,520
tides on mars phobos does raise the tide

1399
00:54:21,990 --> 00:54:20,480
but it's not

1400
00:54:23,750 --> 00:54:22,000
it wouldn't be strong enough to produce

1401
00:54:26,470 --> 00:54:23,760
any strong quakes

1402
00:54:28,549 --> 00:54:26,480
or stresses in the cross the lithosphere

1403
00:54:31,670 --> 00:54:28,559
or the interior of the planet

1404
00:54:34,390 --> 00:54:31,680
that would you know

1405
00:54:35,589 --> 00:54:34,400
release any type of or produce any type

1406
00:54:38,630 --> 00:54:35,599
of seismicity as

1407
00:54:42,309 --> 00:54:38,640
as we see it at least we haven't seen

1408
00:54:46,870 --> 00:54:44,309
and we have time for two more questions

1409
00:54:52,789 --> 00:54:46,880
so sonja on facebook asks

1410
00:54:55,030 --> 00:54:52,799
what's the mission going to look at next

1411
00:54:56,390 --> 00:54:55,040
maybe i can take a step at that i mean

1412
00:54:58,390 --> 00:54:56,400
one of the one of the

1413
00:55:00,710 --> 00:54:58,400

one of the interesting things with

1414
00:55:02,630 --> 00:55:00,720
regard to the core

1415
00:55:04,470 --> 00:55:02,640
sabine has been talking a lot about the

1416
00:55:07,030 --> 00:55:04,480
magnetic field is of course

1417
00:55:07,670 --> 00:55:07,040
the question of whether the earth um i'm

1418
00:55:10,630 --> 00:55:07,680
sorry

1419
00:55:12,069 --> 00:55:10,640
mars has a solid inner core like the

1420
00:55:16,069 --> 00:55:12,079
earth has

1421
00:55:17,910 --> 00:55:16,079
and likely it doesn't but

1422
00:55:19,750 --> 00:55:17,920
then again we don't really know right we

1423
00:55:21,589 --> 00:55:19,760
have to go down and

1424
00:55:25,349 --> 00:55:21,599
you know dig into the data and look for

1425
00:55:29,030 --> 00:55:27,190
very likely going to be a very difficult

1426
00:55:30,390 --> 00:55:29,040
problem and another one of those things

1427
00:55:31,510 --> 00:55:30,400
where you have to look for the needle in

1428
00:55:34,549 --> 00:55:31,520
the haystack

1429
00:55:36,230 --> 00:55:34,559
but if mars contains um you know the

1430
00:55:39,750 --> 00:55:36,240
equivalent of these

1431
00:55:42,230 --> 00:55:39,760
and in a core then it it is in the data

1432
00:55:43,190 --> 00:55:42,240
and it's about trying to you know to

1433
00:55:52,549 --> 00:55:43,200
extract

1434
00:55:58,069 --> 00:55:53,990
mark savino would you like to add to

1435
00:56:01,349 --> 00:56:00,710
so yeah i agree i'm i'm most interested

1436
00:56:10,950 --> 00:56:01,359
in

1437
00:56:12,950 --> 00:56:10,960
bigger earthquakes as us

1438
00:56:14,470 --> 00:56:12,960

mars quakes as well that would be very

1439
00:56:16,870 --> 00:56:14,480
helpful um

1440
00:56:18,069 --> 00:56:16,880
and from the right location so that we

1441
00:56:21,349 --> 00:56:18,079
can see them

1442
00:56:22,309 --> 00:56:21,359
at the insight lander so um everyone

1443
00:56:24,150 --> 00:56:22,319
cross your fingers

1444
00:56:27,430 --> 00:56:24,160
and keep wishing and and hope that this

1445
00:56:31,670 --> 00:56:29,670
yeah and i just say we're continuing to

1446
00:56:35,190 --> 00:56:31,680
listen we're recording right now

1447
00:56:35,910 --> 00:56:35,200
um so we're we're getting new quakes all

1448
00:56:37,510 --> 00:56:35,920
the time

1449
00:56:39,510 --> 00:56:37,520
um and there's still a lot of mysteries

1450
00:56:41,109 --> 00:56:39,520
about the quakes themselves uh the ones

1451
00:56:42,150 --> 00:56:41,119
we're talking about that we've used for

1452
00:56:44,150 --> 00:56:42,160
these studies are

1453
00:56:46,069 --> 00:56:44,160
all a type of quake that we call either

1454
00:56:49,109 --> 00:56:46,079
low frequency or broadband and

1455
00:56:50,069 --> 00:56:49,119
and these look a lot like um earthquakes

1456
00:56:51,990 --> 00:56:50,079
in a lot of ways we

1457
00:56:53,349 --> 00:56:52,000
we we have a pretty uh good

1458
00:56:55,349 --> 00:56:53,359
understanding of how of

1459
00:56:57,030 --> 00:56:55,359
of how they work but there's also

1460
00:56:57,670 --> 00:56:57,040
different types of quakes we're seeing

1461
00:57:00,309 --> 00:56:57,680
that are

1462
00:57:01,750 --> 00:57:00,319
called we have a whole suite of names

1463
00:57:03,750 --> 00:57:01,760

for them high frequency

1464
00:57:04,870 --> 00:57:03,760
very high frequency even super high

1465
00:57:06,789 --> 00:57:04,880
frequency

1466
00:57:07,910 --> 00:57:06,799
um and they're all different and they

1467
00:57:09,670 --> 00:57:07,920
have lots of

1468
00:57:12,150 --> 00:57:09,680
weird properties that we don't totally

1469
00:57:13,670 --> 00:57:12,160
understand um and so you know

1470
00:57:15,270 --> 00:57:13,680
the more of that data we can get and

1471
00:57:16,630 --> 00:57:15,280
look at the statistics of when they

1472
00:57:18,630 --> 00:57:16,640
happen and all of that those are all a

1473
00:57:19,030 --> 00:57:18,640
lot of questions we'd like to understand

1474
00:57:23,030 --> 00:57:19,040
um

1475
00:57:23,990 --> 00:57:23,040
you for understanding all of them yet

1476
00:57:25,670 --> 00:57:24,000
and hopefully

1477
00:57:28,789 --> 00:57:25,680
after some more data we'll we'll have

1478
00:57:31,910 --> 00:57:28,799
better answers for that sort of stuff

1479
00:57:34,390 --> 00:57:31,920
well this is a good segue into our ad

1480
00:57:35,990 --> 00:57:34,400
go ahead sorry just i'll just also

1481
00:57:36,950 --> 00:57:36,000
quickly add that one thing that's been

1482
00:57:38,390 --> 00:57:36,960
great about

1483
00:57:40,710 --> 00:57:38,400
the length of time of the insight

1484
00:57:41,270 --> 00:57:40,720
mission is that so mars's year is about

1485
00:57:43,270 --> 00:57:41,280
twice

1486
00:57:44,630 --> 00:57:43,280
that of earth's year the amount of time

1487
00:57:46,710 --> 00:57:44,640
it takes to go around

1488
00:57:48,309 --> 00:57:46,720

the sun in its orbit and so we're also

1489
00:57:48,950 --> 00:57:48,319
able to now because we've been there for

1490
00:57:51,190 --> 00:57:48,960
so long

1491
00:57:53,510 --> 00:57:51,200
look for seasonal effects look for you

1492
00:57:54,549 --> 00:57:53,520
know since we have repeats of the mars

1493
00:57:56,150 --> 00:57:54,559
seasons

1494
00:57:57,430 --> 00:57:56,160
and so i think that's also an

1495
00:58:00,390 --> 00:57:57,440
interesting thing we're going to be

1496
00:58:05,670 --> 00:58:04,150
that kind of segues into this final

1497
00:58:08,390 --> 00:58:05,680
question that i have that we can

1498
00:58:08,950 --> 00:58:08,400
i want each of you to quickly answer joe

1499
00:58:11,910 --> 00:58:08,960
on youtube

1500
00:58:13,910 --> 00:58:11,920
asks based on all your findings what

1501
00:58:14,710 --> 00:58:13,920
would be the next generation of

1502
00:58:17,430 --> 00:58:14,720
instruments

1503
00:58:17,990 --> 00:58:17,440
you would like to see sent to mars for

1504
00:58:21,510 --> 00:58:18,000
further

1505
00:58:23,510 --> 00:58:21,520
understanding oh i see sabina like

1506
00:58:25,750 --> 00:58:23,520
getting excited about that one would you

1507
00:58:29,030 --> 00:58:25,760
like to go first

1508
00:58:29,510 --> 00:58:29,040
sure um i think that there is a whole

1509
00:58:33,109 --> 00:58:29,520
lot of

1510
00:58:35,109 --> 00:58:33,119
opportunity in things like drones or

1511
00:58:36,789 --> 00:58:35,119
helicopters right we have ginny there

1512
00:58:40,150 --> 00:58:36,799
right now

1513
00:58:40,870 --> 00:58:40,160

the ability to to move around and get

1514
00:58:43,510 --> 00:58:40,880
information

1515
00:58:44,789 --> 00:58:43,520
from different places on the surface

1516
00:58:46,230 --> 00:58:44,799
that would be

1517
00:58:47,829 --> 00:58:46,240
really great in terms of learning about

1518
00:58:49,990 --> 00:58:47,839
the next generation we want to have

1519
00:58:52,470 --> 00:58:50,000
information about the magnetic field

1520
00:58:54,150 --> 00:58:52,480
the surface properties the gravity um

1521
00:58:55,670 --> 00:58:54,160
seismicity we want it from a lot of

1522
00:58:57,750 --> 00:58:55,680
different locations

1523
00:58:58,789 --> 00:58:57,760
so the more we can do that the more

1524
00:59:02,390 --> 00:58:58,799
we're going to learn about the interior

1525
00:59:08,870 --> 00:59:05,670
like to go next mark uh sure

1526
00:59:12,549 --> 00:59:08,880
uh yeah so um for me i i

1527
00:59:14,470 --> 00:59:12,559
i 100 agree with sabina that you know um

1528
00:59:15,750 --> 00:59:14,480
more and more locations and you know

1529
00:59:18,230 --> 00:59:15,760
connected with that

1530
00:59:19,990 --> 00:59:18,240
um one of the big challenges we have an

1531
00:59:21,750 --> 00:59:20,000
insight is that we're trying to locate

1532
00:59:23,030 --> 00:59:21,760
events with one station and you know if

1533
00:59:25,349 --> 00:59:23,040
you took an intro class

1534
00:59:27,430 --> 00:59:25,359
they they teach you somewhat incorrectly

1535
00:59:28,470 --> 00:59:27,440
that you need three stations to locate a

1536
00:59:30,150 --> 00:59:28,480
a quake

1537
00:59:32,710 --> 00:59:30,160
um we've proven that you can do a lot

1538
00:59:35,349 --> 00:59:32,720

with one station and we can locate a

1539
00:59:37,589 --> 00:59:35,359
uh quakes with with one station but the

1540
00:59:39,670 --> 00:59:37,599
factory means it's still a lot easier to

1541
00:59:40,630 --> 00:59:39,680
do a lot of seismology if you have more

1542
00:59:43,430 --> 00:59:40,640
stations

1543
00:59:44,630 --> 00:59:43,440
and so um you know there are options you

1544
00:59:46,870 --> 00:59:44,640
can imagine

1545
00:59:48,470 --> 00:59:46,880
a global network of stations that are

1546
00:59:49,750 --> 00:59:48,480
really sensitive and are measuring like

1547
00:59:52,230 --> 00:59:49,760
what we're doing um

1548
00:59:53,589 --> 00:59:52,240
and just really nailing down the global

1549
00:59:55,349 --> 00:59:53,599
picture of what's happening with

1550
00:59:57,030 --> 00:59:55,359
seismology and then maybe looking at

1551
00:59:59,109 --> 00:59:57,040
variations in crystal thickness

1552
01:00:00,950 --> 00:59:59,119
or you could imagine local networks that

1553
01:00:04,069 --> 01:00:00,960
are looking at areas of interest like

1554
01:00:05,750 --> 01:00:04,079
cerberus fosse or or or tharsis

1555
01:00:07,109 --> 01:00:05,760
um where you could get away with maybe

1556
01:00:08,549 --> 01:00:07,119
having less sensitive stations because

1557
01:00:11,190 --> 01:00:08,559
you're sitting right where you know

1558
01:00:12,309 --> 01:00:11,200
quakes are are active and so maybe you

1559
01:00:15,109 --> 01:00:12,319
could have

1560
01:00:16,390 --> 01:00:15,119
keep landers with with with uh uh less

1561
01:00:18,950 --> 01:00:16,400
expensive sensors

1562
01:00:20,230 --> 01:00:18,960
um and and get networks and and really

1563
01:00:22,630 --> 01:00:20,240

get into understanding

1564
01:00:23,349 --> 01:00:22,640
locations of these small events that we

1565
01:00:27,109 --> 01:00:23,359
can't really

1566
01:00:30,230 --> 01:00:27,119
locate with one station with insight

1567
01:00:32,309 --> 01:00:30,240
and then amir yeah i think i

1568
01:00:34,390 --> 01:00:32,319
i i share the optimism of mark and

1569
01:00:35,910 --> 01:00:34,400
sabine but i think we still have in the

1570
01:00:38,069 --> 01:00:35,920
light of what we have learned now and

1571
01:00:39,750 --> 01:00:38,079
what we've seen with a single station

1572
01:00:41,910 --> 01:00:39,760
and we've done a lot with a single

1573
01:00:42,390 --> 01:00:41,920
station right and it's amazing it's it's

1574
01:00:44,069 --> 01:00:42,400
it's

1575
01:00:45,430 --> 01:00:44,079
outstanding the stuff that we've been

1576
01:00:47,589 --> 01:00:45,440
able to do

1577
01:00:48,789 --> 01:00:47,599
um but i still think that we have to

1578
01:00:51,430 --> 01:00:48,799
keep in mind that

1579
01:00:52,870 --> 01:00:51,440
you know we have all these different you

1580
01:00:54,870 --> 01:00:52,880
know geophysical methods

1581
01:00:56,470 --> 01:00:54,880
uh you know like you look at magnetic

1582
01:00:59,589 --> 01:00:56,480
fields and gravity

1583
01:01:01,349 --> 01:00:59,599
and stuff like that but you know we have

1584
01:01:03,510 --> 01:01:01,359
to keep in mind that seismology is the

1585
01:01:05,430 --> 01:01:03,520
gold standard in the sense that it is

1586
01:01:06,870 --> 01:01:05,440
the geophysical method that has

1587
01:01:09,670 --> 01:01:06,880
you know that gives you the highest

1588
01:01:13,750 --> 01:01:09,680

resolution when you look inside a planet

1589
01:01:17,910 --> 01:01:16,150
we've been talking a lot about i don't

1590
01:01:19,190 --> 01:01:17,920
know make this a long story but we've

1591
01:01:20,950 --> 01:01:19,200
been talking a lot about the you know

1592
01:01:23,270 --> 01:01:20,960
the the the

1593
01:01:24,390 --> 01:01:23,280
the broadband seismometer but there was

1594
01:01:26,710 --> 01:01:24,400
also a short period of

1595
01:01:27,829 --> 01:01:26,720
moment on there which is based on men's

1596
01:01:29,670 --> 01:01:27,839
technology and

1597
01:01:31,829 --> 01:01:29,680
you know it's light it's compact it

1598
01:01:34,069 --> 01:01:31,839
doesn't it doesn't weigh anything

1599
01:01:36,069 --> 01:01:34,079
and you know you could send stuff like

1600
01:01:36,870 --> 01:01:36,079
that but unfortunately what it's turned

1601
01:01:38,549 --> 01:01:36,880
out is that

1602
01:01:40,230 --> 01:01:38,559
you know a lot of the stuff a lot of the

1603
01:01:42,549 --> 01:01:40,240
stuff you know the the the

1604
01:01:43,829 --> 01:01:42,559
marsquakes that we've been using to look

1605
01:01:46,069 --> 01:01:43,839
inside the planet

1606
01:01:48,309 --> 01:01:46,079
have really only been picked up properly

1607
01:01:50,950 --> 01:01:48,319
by the broadband seismometer

1608
01:01:52,710 --> 01:01:50,960
so i think you know going back and doing

1609
01:01:54,630 --> 01:01:52,720
arrays and you know

1610
01:01:56,390 --> 01:01:54,640
tens of stations stuff of course we'd

1611
01:01:59,029 --> 01:01:56,400
love to do that and we'd like to dream

1612
01:02:01,349 --> 01:01:59,039
about magnitude fives and sixes but

1613
01:02:02,710 --> 01:02:01,359

you know these these particular the

1614
01:02:04,390 --> 01:02:02,720
seismometer that mars

1615
01:02:06,150 --> 01:02:04,400
that mark talked about and showed on the

1616
01:02:09,029 --> 01:02:06,160
images you know they they

1617
01:02:10,950 --> 01:02:09,039
are built specifically and you know in

1618
01:02:13,349 --> 01:02:10,960
laboratories for these types of missions

1619
01:02:15,510 --> 01:02:13,359
and it's not something that's simply

1620
01:02:16,630 --> 01:02:15,520
you know packaged and moved elsewhere

1621
01:02:18,710 --> 01:02:16,640
right so

1622
01:02:19,990 --> 01:02:18,720
it's a little more difficult than that

1623
01:02:21,670 --> 01:02:20,000
if you want

1624
01:02:24,069 --> 01:02:21,680
the type of stuff that we've been able

1625
01:02:24,870 --> 01:02:24,079
to do on on mars with insight but i

1626
01:02:28,870 --> 01:02:24,880
think

1627
01:02:30,950 --> 01:02:28,880
the you know the fact that we've been

1628
01:02:31,430 --> 01:02:30,960
able to do so much with a single station

1629
01:02:34,630 --> 01:02:31,440
is

1630
01:02:37,750 --> 01:02:34,640
the way for

1631
01:02:39,190 --> 01:02:37,760
for for future missions because you can

1632
01:02:41,910 --> 01:02:39,200
just take a single station

1633
01:02:43,589 --> 01:02:41,920
and you know move from there place it on

1634
01:02:43,990 --> 01:02:43,599
a different location of the planet of

1635
01:02:47,430 --> 01:02:44,000
course

1636
01:02:47,990 --> 01:02:47,440
but we're all dreaming of big mars

1637
01:02:50,470 --> 01:02:48,000
quakes like

1638
01:02:51,270 --> 01:02:50,480

you said that is all the time we have

1639
01:02:53,190 --> 01:02:51,280
today

1640
01:02:55,670 --> 01:02:53,200
and i'd like to thank everyone for their

1641
01:02:57,109 --> 01:02:55,680
questions and thank you to the team for

1642
01:02:59,829 --> 01:02:57,119
chatting with us today

1643
01:03:01,510 --> 01:02:59,839
now for more information and to stay up

1644
01:03:05,190 --> 01:03:01,520
to date with the mission

1645
01:03:08,470 --> 01:03:05,200
visit mars.nasa.gov insight