1
00:00:09,650 --> 00:00:07,820
good afternoon my name is Dorian Brown

2
00:00:12,650 --> 00:00:09,660
with the Office of Communications and

3
00:00:15,350 --> 00:00:12,660
welcome to NASA headquarters today

4
00:00:18,140 --> 00:00:15,360
science update will feature new theories

5
00:00:22,130 --> 00:00:18,150
concerning Jupiter's icy moon Europa

6
00:00:25,210 --> 00:00:22,140
more specifically Hidden Lakes when

7
00:00:28,970 --> 00:00:25,220
Europa in fact what you will hear today

8
00:00:31,279 --> 00:00:28,980
opens up compelling possibilities in the

9
00:00:33,940 --> 00:00:31,289
search for life elsewhere in the

10
00:00:38,450 --> 00:00:33,950
universe and the findings I published in

11
00:00:40,160 --> 00:00:38,460
the journal Nature we're going to have

12
00:00:41,720 --> 00:00:40,170
brief presentations from my speakers

13
00:00:43,610 --> 00:00:41,730

then we'll open it up for questions

14
00:00:46,220 --> 00:00:43,620
starting here in Washington on NASA

15
00:00:48,229 --> 00:00:46,230
centers and our phone lines before we

16
00:00:53,029 --> 00:00:48,239
get started let me introduce you to

17
00:00:59,360 --> 00:00:53,039
today's speakers first up Brittany

18
00:01:02,330 --> 00:00:59,370
Schmidt post-doctorate fellow Institute

19
00:01:08,710 --> 00:01:02,340
for geophysics University of Texas and

20
00:01:12,530 --> 00:01:08,720
Austin Tom Wagner program scientists

21
00:01:16,990 --> 00:01:12,540
across spheric sciences prep science

22
00:01:23,719 --> 00:01:21,320
sorry polar astrobiologists and senior

23
00:01:27,789 --> 00:01:23,729
research scientist NASA's Ames Research

24
00:01:35,359 --> 00:01:33,319
Annelise Proctor planetary scientists at

25
00:01:39,230 --> 00:01:35,369
the Johns Hopkins University Applied

26
00:01:41,810 --> 00:01:39,240
Physics Laboratory in Laurel Maryland so

27
00:01:44,660 --> 00:01:41,820
let's get started and I'll toss it over

28
00:01:46,730 --> 00:01:44,670
to Brittany thanks Wayne well I'm

29
00:01:49,280 --> 00:01:46,740
excited to be here with you today to

30
00:01:52,580 --> 00:01:49,290
tell you a little bit about an icy moon

31
00:01:55,010 --> 00:01:52,590
of Jupiter called Europa which we will

32
00:01:58,459 --> 00:01:55,020
show today evidence from recent work

33
00:02:01,730 --> 00:01:58,469
that my team has done my team Don

34
00:02:04,910 --> 00:02:01,740
Blankenship west paterson and paul shank

35
00:02:08,839 --> 00:02:04,920
and i have worked really hard on this

36
00:02:10,520 --> 00:02:08,849
project and if to put jupiter to put a

37
00:02:12,920 --> 00:02:10,530
rope in a little bit of context this is

38
00:02:13,700 --> 00:02:12,930

an image of Europa if you were to look

39
00:02:16,340 --> 00:02:13,710
up into the night

40
00:02:18,800 --> 00:02:16,350
sky tonight much like Galileo did 400

41
00:02:20,390 --> 00:02:18,810
years ago you would see the brightest

42
00:02:22,670 --> 00:02:20,400
point of light in the sky is actually

43
00:02:24,470 --> 00:02:22,680
Jupiter and if you looked at it with

44
00:02:26,600 --> 00:02:24,480
binoculars or a small telescope you'd

45
00:02:28,970 --> 00:02:26,610
notice four tiny bright flashes of light

46
00:02:31,550 --> 00:02:28,980
these are the Galilean satellites of

47
00:02:34,100 --> 00:02:31,560
these Europa is the second most our

48
00:02:36,290 --> 00:02:34,110
second innermost moon and the first icy

49
00:02:39,140 --> 00:02:36,300
moon of Jupiter Europa is covered by a

50
00:02:42,590 --> 00:02:39,150
thick layer of ice containing a

51
00:02:45,440 --> 00:02:42,600
subsurface ocean and then a deeper rocky

52
00:02:47,180 --> 00:02:45,450
mantle and possibly iron core we're

53
00:02:49,910 --> 00:02:47,190
excited about Europa because it

54
00:02:52,370 --> 00:02:49,920
represents a place that's somehow alien

55
00:02:55,370 --> 00:02:52,380
and yet strangely familiar and maybe a

56
00:02:58,310 --> 00:02:55,380
place where there's existence of life in

57
00:03:00,710 --> 00:02:58,320
the solar system today and so I'm

58
00:03:03,590 --> 00:03:00,720
excited to tell you about lakes on

59
00:03:08,690 --> 00:03:03,600
Europa so if I could have the first

60
00:03:10,790 --> 00:03:08,700
graphic these are two images of geologic

61
00:03:12,800 --> 00:03:10,800
terrain taken by the Galileo spacecraft

62
00:03:15,860 --> 00:03:12,810
and they show what's called chaos

63
00:03:18,290 --> 00:03:15,870

terrain these are broken up regions of

64
00:03:20,690 --> 00:03:18,300
the surface characterized by a hummocky

65
00:03:24,200 --> 00:03:20,700
Brown textured material we call matrix

66
00:03:27,140 --> 00:03:24,210
and large icebergs in many cases which

67
00:03:28,970 --> 00:03:27,150
you can see in both of these images one

68
00:03:30,800 --> 00:03:28,980
of the motivations for this study was to

69
00:03:34,760 --> 00:03:30,810
try to understand why are these two

70
00:03:37,880 --> 00:03:34,770
features so similar and so different on

71
00:03:39,710 --> 00:03:37,890
the Left you're seeing thera macula and

72
00:03:42,170 --> 00:03:39,720
on the right you're saying connemara

73
00:03:45,080 --> 00:03:42,180
chaos connemara chaos is in fact perhaps

74
00:03:48,530 --> 00:03:45,090
the archetype of chaos terrain and gives

75
00:03:49,970 --> 00:03:48,540
us a picture of what Europa's activity

76
00:03:51,110 --> 00:03:49,980
may have looked like and it's been

77
00:03:53,300 --> 00:03:51,120
thought for some time that this

78
00:03:55,850 --> 00:03:53,310
represented the interaction of ice and

79
00:03:59,870 --> 00:03:55,860
water but how that how that actually

80
00:04:03,440 --> 00:03:59,880
works out has been has needed more

81
00:04:06,440 --> 00:04:03,450
explanation and so we went to work on

82
00:04:09,830 --> 00:04:06,450
trying to understand this and so the way

83
00:04:12,380 --> 00:04:09,840
that we gave perspective to the problem

84
00:04:14,180 --> 00:04:12,390
of chaos formation on Europa was to look

85
00:04:17,270 --> 00:04:14,190
at environments on earth where water and

86
00:04:20,000 --> 00:04:17,280
ice interact these two important analogs

87
00:04:22,840 --> 00:04:20,010
or examples of this process here on

88
00:04:26,060 --> 00:04:22,850

earth are sub Glacial volcanoes and

89
00:04:27,230 --> 00:04:26,070
collapsing ice shelves and so in a sub

90
00:04:28,610 --> 00:04:27,240
glacial volcano as

91
00:04:31,010 --> 00:04:28,620
essentially what you have is a heat

92
00:04:33,770 --> 00:04:31,020
source underneath the thick cover of ice

93
00:04:37,150 --> 00:04:33,780
and what it does is to create localized

94
00:04:40,100 --> 00:04:37,160
melt that actually forms a lens shaped

95
00:04:42,559 --> 00:04:40,110
lens shaped lake just below the surface

96
00:04:44,270 --> 00:04:42,569
of the ice what's interesting about that

97
00:04:46,150 --> 00:04:44,280
is that the water kind of sits there and

98
00:04:48,680 --> 00:04:46,160
gets to interact with the ice above in

99
00:04:50,719 --> 00:04:48,690
Antarctica we see great examples of

100
00:04:52,400 --> 00:04:50,729
collapsing ice shelves what these ice

101
00:04:54,680 --> 00:04:52,410
shelves do is they sit there for

102
00:04:56,990 --> 00:04:54,690
millions of years and then fill up with

103
00:04:58,760 --> 00:04:57,000
fractures and then break under their own

104
00:05:00,080 --> 00:04:58,770
weight or with help from the water that

105
00:05:02,960 --> 00:05:00,090
gets into fractures in those

106
00:05:04,969 --> 00:05:02,970
environments and so with that context we

107
00:05:06,439 --> 00:05:04,979
formulated a model for how Europa might

108
00:05:08,089 --> 00:05:06,449
work so I'm going to show you a little

109
00:05:13,370 --> 00:05:08,099
demonstration before I show you an image

110
00:05:15,559 --> 00:05:13,380
so if you imagine that we start off with

111
00:05:18,379 --> 00:05:15,569
Europa basically made up of ice that's

112
00:05:20,390 --> 00:05:18,389
fractured but basically just sitting

113
00:05:22,490 --> 00:05:20,400

there and then we add some water this

114
00:05:24,260 --> 00:05:22,500
water comes up from below is cause it's

115
00:05:26,180 --> 00:05:24,270
melting that's caused by a plume of

116
00:05:28,670 --> 00:05:26,190
material much like a mantle plume on the

117
00:05:31,550 --> 00:05:28,680
earth coming up underneath this brittle

118
00:05:33,560 --> 00:05:31,560
ice and filling it up with water as the

119
00:05:35,570 --> 00:05:33,570
lake forms you actually start to see the

120
00:05:37,399 --> 00:05:35,580
icebergs float you've noticed that these

121
00:05:39,469 --> 00:05:37,409
have been turning around and rotating in

122
00:05:41,330 --> 00:05:39,479
the glass in the case of Europa there's

123
00:05:44,839 --> 00:05:41,340
also a thick material called matrix

124
00:05:46,610 --> 00:05:44,849
material that's crushed up ice that

125
00:05:48,439 --> 00:05:46,620
sticks also on the surface of the water

126
00:05:50,209 --> 00:05:48,449
so you never have liquid water really on

127
00:05:52,219 --> 00:05:50,219
the surface but the water is actually

128
00:05:54,740 --> 00:05:52,229
causing the icebergs to float and rotate

129
00:05:56,209 --> 00:05:54,750
and to break up the ice around it what's

130
00:05:58,520 --> 00:05:56,219
interesting is that if you were to go

131
00:06:01,309 --> 00:05:58,530
back and look at this particular Lake on

132
00:06:02,930 --> 00:06:01,319
Europa much later it would actually be

133
00:06:04,670 --> 00:06:02,940
frozen out it may be resemble something

134
00:06:07,219 --> 00:06:04,680
like this where you've got icebergs and

135
00:06:10,219 --> 00:06:07,229
matrix material pushed up but the entire

136
00:06:11,719 --> 00:06:10,229
thing frozen out and so in the next

137
00:06:13,159 --> 00:06:11,729
slide we have an image of what that

138
00:06:15,230 --> 00:06:13,169

process might look like it's just a

139
00:06:17,719 --> 00:06:15,240
cartoon image on the Left we're showing

140
00:06:19,999 --> 00:06:17,729
a collapsing Lake with icebergs popped

141
00:06:21,740 --> 00:06:20,009
up above the surface and imaged and the

142
00:06:24,820 --> 00:06:21,750
matrix materials starting to fill up

143
00:06:27,290 --> 00:06:24,830
with salt rich water from the lake below

144
00:06:28,969 --> 00:06:27,300
this is the process that breaks up the

145
00:06:31,969 --> 00:06:28,979
surface and causes it to look the way we

146
00:06:34,279 --> 00:06:31,979
think it does on the right hand side we

147
00:06:37,339 --> 00:06:34,289
see a snapshot of this process much

148
00:06:39,379 --> 00:06:37,349
later once the ice or once the water in

149
00:06:41,060 --> 00:06:39,389
the lake has actually frozen out one of

150
00:06:42,920 --> 00:06:41,070
the interesting observations of your

151
00:06:44,330 --> 00:06:42,930
has been that there are Kaos features

152
00:06:46,670 --> 00:06:44,340
that are dropped down below the surface

153
00:06:48,440 --> 00:06:46,680
and cast features they're perched up

154
00:06:51,230 --> 00:06:48,450
above the surface with these dome-like

155
00:06:53,810 --> 00:06:51,240
textures they always have in common some

156
00:06:55,520 --> 00:06:53,820
icebergs or some broken up material but

157
00:06:57,470 --> 00:06:55,530
ones down and ones high and what this

158
00:07:00,050 --> 00:06:57,480
does is to put those in perspective as

159
00:07:01,820 --> 00:07:00,060
kind of like a time scale drop down

160
00:07:05,060 --> 00:07:01,830
means active today with liquid water

161
00:07:08,240 --> 00:07:05,070
lens and frozen out is popped up above

162
00:07:10,130 --> 00:07:08,250
the surface with domes and and and solid

163
00:07:12,440 --> 00:07:10,140

icebergs and so if you go to the next

164
00:07:14,690 --> 00:07:12,450
slide this is that first image that I

165
00:07:16,070 --> 00:07:14,700
showed you of the two Kaos terrains but

166
00:07:17,870 --> 00:07:16,080
in fact in this case we're showing you

167
00:07:21,470 --> 00:07:17,880
the topography overlaid on top of the

168
00:07:24,140 --> 00:07:21,480
image in this image blue means low and

169
00:07:26,060 --> 00:07:24,150
red means high if you look at the image

170
00:07:28,130 --> 00:07:26,070
on the Left which is thera macula you'll

171
00:07:30,590 --> 00:07:28,140
notice that the center of the feature is

172
00:07:33,470 --> 00:07:30,600
depressed down below the surface in fact

173
00:07:35,450 --> 00:07:33,480
as much as 400 to 800 meters which means

174
00:07:38,420 --> 00:07:35,460
that a giant pocket of liquid water

175
00:07:40,040 --> 00:07:38,430
still exists below this body today was

176
00:07:42,320 --> 00:07:40,050
also interesting is just like in this

177
00:07:44,450 --> 00:07:42,330
glass of water the icebergs are popped

178
00:07:46,250 --> 00:07:44,460
up above the surface if we look on the

179
00:07:48,350 --> 00:07:46,260
right image of Connemara chaos you'll

180
00:07:50,750 --> 00:07:48,360
notice that instead the terrain is much

181
00:07:52,580 --> 00:07:50,760
lumpier and it's characterized by this

182
00:07:54,620 --> 00:07:52,590
reddish color which means that the

183
00:07:56,780 --> 00:07:54,630
surface is popped up and it's filled

184
00:07:58,880 --> 00:07:56,790
with water and then frozen and so on the

185
00:08:01,070 --> 00:07:58,890
Left we have an active feature on the

186
00:08:02,930 --> 00:08:01,080
right we have an older feature that had

187
00:08:05,090 --> 00:08:02,940
a lake at one time but might have

188
00:08:07,070 --> 00:08:05,100

already frozen out today we've also

189
00:08:09,170 --> 00:08:07,080
prepared a video for you of the profile

190
00:08:12,440 --> 00:08:09,180
the process might look on Europa so

191
00:08:14,750 --> 00:08:12,450
we're going to show you that as we come

192
00:08:17,930 --> 00:08:14,760
into the video you're going to see we're

193
00:08:20,060 --> 00:08:17,940
flying by Jupiter zooming into Europa

194
00:08:22,310 --> 00:08:20,070
that second second moon of Jupiter

195
00:08:24,650 --> 00:08:22,320
covered with ice and we're snapping into

196
00:08:26,540 --> 00:08:24,660
a thin section so you can see in fact

197
00:08:28,700 --> 00:08:26,550
the process start to happen if you

198
00:08:31,850 --> 00:08:28,710
notice there's warm ice down from the

199
00:08:35,030 --> 00:08:31,860
bottom right near the ocean interface

200
00:08:37,040 --> 00:08:35,040
moving its way up causing warming and

201
00:08:38,810 --> 00:08:37,050
causing melting kind of right in the

202
00:08:40,880 --> 00:08:38,820
middle of the ice shell as that lake

203
00:08:43,459 --> 00:08:40,890
starts to form it brings the surface

204
00:08:46,010 --> 00:08:43,469
down because water takes up less volume

205
00:08:47,930 --> 00:08:46,020
than the ice it replaces so the surface

206
00:08:50,270 --> 00:08:47,940
collapses down the icebergs start to

207
00:08:52,730 --> 00:08:50,280
float around break up the ice around it

208
00:08:54,430 --> 00:08:52,740
and then as it refreezes it's free to

209
00:08:56,139 --> 00:08:54,440
dome back up and

210
00:08:58,840 --> 00:08:56,149
the features that we see today that look

211
00:09:00,910 --> 00:08:58,850
like connemara chaos so this is in fact

212
00:09:04,720 --> 00:09:00,920
what we think it might be like on Europa

213
00:09:07,030 --> 00:09:04,730

as these features are forming and to

214
00:09:09,550 --> 00:09:07,040
turn back to the earth example here is a

215
00:09:11,860 --> 00:09:09,560
video of this process happening in a

216
00:09:13,929 --> 00:09:11,870
Greenland a very similar process what

217
00:09:16,600 --> 00:09:13,939
you're looking at is Jakob saman glacier

218
00:09:19,420 --> 00:09:16,610
as icebergs calve from the front of the

219
00:09:21,579 --> 00:09:19,430
glacier turn over and exist there you go

220
00:09:25,030 --> 00:09:21,589
big big iceberg flipping over and

221
00:09:27,189 --> 00:09:25,040
floating around in a matrix of broken up

222
00:09:29,679 --> 00:09:27,199
brash eyes which is rich in water but

223
00:09:31,090 --> 00:09:29,689
still really a solid so this is what it

224
00:09:35,050 --> 00:09:31,100
might look like on Europa if we were

225
00:09:36,790 --> 00:09:35,060
witnessing it relatively live so Tom

226
00:09:38,350 --> 00:09:36,800
Wagner is going to tell you a little bit

227
00:09:40,329 --> 00:09:38,360
more about the Earth's frozen

228
00:09:43,749 --> 00:09:40,339
environments and if we could have the

229
00:09:45,220 --> 00:09:43,759
first slide I thought we'd start with

230
00:09:46,749 --> 00:09:45,230
just a really brief description of ice

231
00:09:48,460 --> 00:09:46,759
shelves which as brittany pointed out is

232
00:09:50,650 --> 00:09:48,470
probably our best analog for what's

233
00:09:51,999 --> 00:09:50,660
happened with the ice on Europa and what

234
00:09:53,710 --> 00:09:52,009
happens is this you take a place at

235
00:09:55,480 --> 00:09:53,720
Greenland Antarctica you build up a lot

236
00:09:57,340 --> 00:09:55,490
of ice and snow in the middle until it

237
00:09:59,110 --> 00:09:57,350
literally gets miles thick and then it

238
00:10:00,699 --> 00:09:59,120

begins to flow to the sides just like if

239
00:10:02,889 --> 00:10:00,709
I poured honey on the table right here

240
00:10:04,300 --> 00:10:02,899
how it would flow out but what happens

241
00:10:06,639 --> 00:10:04,310
when that ice hits the ocean is that

242
00:10:09,280 --> 00:10:06,649
begins to float and that floating

243
00:10:11,470 --> 00:10:09,290
glacier is what an ice shelf is they can

244
00:10:14,170 --> 00:10:11,480
be many hundreds of feet thick they can

245
00:10:16,389 --> 00:10:14,180
extend out many many many miles hundreds

246
00:10:17,980 --> 00:10:16,399
of miles in some cases in fact the Ross

247
00:10:21,730 --> 00:10:17,990
Ice Shelf is the size of France in

248
00:10:24,100 --> 00:10:21,740
Antarctica next slide but ice shelves

249
00:10:25,600 --> 00:10:24,110
are also remarkably dynamic features

250
00:10:28,990 --> 00:10:25,610
most people had thought they were kind

251
00:10:30,600 --> 00:10:29,000
of stable but here we saw in 2008 the

252
00:10:32,650 --> 00:10:30,610
Wilkins ice shelf in Antarctica

253
00:10:34,509 --> 00:10:32,660
literally over the course of a couple of

254
00:10:36,579 --> 00:10:34,519
weeks it blew apart and one of what my

255
00:10:38,920 --> 00:10:36,589
colleagues describes as the mosh pit and

256
00:10:40,660 --> 00:10:38,930
what happened was this ice as it flowed

257
00:10:42,100 --> 00:10:40,670
out it got a little thinner eventually

258
00:10:43,480 --> 00:10:42,110
it triggered a collapse which then

259
00:10:45,819 --> 00:10:43,490
triggered a further collapse and it

260
00:10:48,400 --> 00:10:45,829
tumbled away like giant dominoes next

261
00:10:50,679 --> 00:10:48,410
slide some of these dominoes though are

262
00:10:52,929 --> 00:10:50,689
miles long and hundreds of feet thick

263
00:10:54,369 --> 00:10:52,939

and they turn over and rotate and also

264
00:10:56,740 --> 00:10:54,379
as brittany point out that matrix

265
00:10:58,210 --> 00:10:56,750
material that we see on europa probably

266
00:11:00,069 --> 00:10:58,220
would look something like this which is

267
00:11:01,929 --> 00:11:00,079
brash ice which is the broken up bits

268
00:11:04,030 --> 00:11:01,939
that fill in beneath these between these

269
00:11:07,299 --> 00:11:04,040
birds as they bump into each other next

270
00:11:08,210 --> 00:11:07,309
slide this process is profoundly

271
00:11:09,980 --> 00:11:08,220
important for us

272
00:11:11,480 --> 00:11:09,990
on earth also and this example is the

273
00:11:12,980 --> 00:11:11,490
Larsen Ice Shelf which is on the

274
00:11:16,220 --> 00:11:12,990
Antarctic Peninsula that extends up

275
00:11:17,990 --> 00:11:16,230
towards South America in 2002 an area

276
00:11:19,400 --> 00:11:18,000
the size of Rhode Island again collapsed

277
00:11:22,100 --> 00:11:19,410
just over the course of a couple of

278
00:11:23,780 --> 00:11:22,110
weeks picture giant tablets just

279
00:11:26,000 --> 00:11:23,790
tumbling away things hundreds of feet

280
00:11:28,880 --> 00:11:26,010
thick right over a giant like as big as

281
00:11:31,280 --> 00:11:28,890
a US state what happened though that was

282
00:11:33,440 --> 00:11:31,290
so remarkable was that the glaciers on

283
00:11:34,850 --> 00:11:33,450
the land behind it off to the left side

284
00:11:37,340 --> 00:11:34,860
of the screen that you're looking at

285
00:11:39,320 --> 00:11:37,350
they sped up dramatically as you kind of

286
00:11:41,000 --> 00:11:39,330
popped the cork or pulled away this ice

287
00:11:43,460 --> 00:11:41,010
shelf some of them increased their speed

288
00:11:45,200 --> 00:11:43,470

Eightfold they went so fast that they

289
00:11:47,510 --> 00:11:45,210
drained all the ice that was behind them

290
00:11:49,580 --> 00:11:47,520
and the surface deflated by over a

291
00:11:52,010 --> 00:11:49,590
hundred and fifty feet in some cases

292
00:11:53,750 --> 00:11:52,020
over six hundred feet in other cases

293
00:11:55,970 --> 00:11:53,760
just over the course of five or six

294
00:11:57,380 --> 00:11:55,980
years so this is really important

295
00:11:59,750 --> 00:11:57,390
because when we try to project future

296
00:12:01,100 --> 00:11:59,760
sea-level rise on the planet we think

297
00:12:02,750 --> 00:12:01,110
that this is probably the most dynamic

298
00:12:04,130 --> 00:12:02,760
element that we have to take into

299
00:12:07,760 --> 00:12:04,140
account because there's ice shelves all

300
00:12:09,080 --> 00:12:07,770
around Antarctica next slide and this is

301
00:12:10,730 --> 00:12:09,090
one of the most important ice shelves

302
00:12:11,690 --> 00:12:10,740
for that sea level rise work that I

303
00:12:15,200 --> 00:12:11,700
spoke about this is the Pine Island

304
00:12:17,120 --> 00:12:15,210
glacier ice shelf and this is we studied

305
00:12:18,290 --> 00:12:17,130
these processes in great detail one

306
00:12:20,270 --> 00:12:18,300
thing you should realize is that it's

307
00:12:22,250 --> 00:12:20,280
not a huge extrapolation to go from what

308
00:12:24,110 --> 00:12:22,260
we're doing on earth to Europa because

309
00:12:25,790 --> 00:12:24,120
we have satellites and aircraft where we

310
00:12:27,950 --> 00:12:25,800
can study these things all the way down

311
00:12:29,420 --> 00:12:27,960
to the base levels in this case what

312
00:12:31,220 --> 00:12:29,430
you're looking at the grey is the

313
00:12:32,900 --> 00:12:31,230

surface of the ice shelf which was shot

314
00:12:34,640 --> 00:12:32,910
by lidar from an aircraft literally a

315
00:12:36,920 --> 00:12:34,650
little laser rastering over the surface

316
00:12:38,480 --> 00:12:36,930
underneath that the next layer that kind

317
00:12:40,310 --> 00:12:38,490
of mountainous coloured stuff is the

318
00:12:42,500 --> 00:12:40,320
base of the ice shelf which was with

319
00:12:44,270 --> 00:12:42,510
radar as amazing as it sounds we can put

320
00:12:45,710 --> 00:12:44,280
a radar under an airplane and map the

321
00:12:47,480 --> 00:12:45,720
structure of the ice and the bottom of

322
00:12:49,130 --> 00:12:47,490
the ice under there would be the ocean

323
00:12:51,410 --> 00:12:49,140
and then the bottom is actually the seat

324
00:12:52,610 --> 00:12:51,420
flow which we map by a gravimeter it's

325
00:12:55,400 --> 00:12:52,620
really important to us because again

326
00:12:57,230 --> 00:12:55,410
like the Europa case where you have warm

327
00:12:59,360 --> 00:12:57,240
water that's causing melting and

328
00:13:01,760 --> 00:12:59,370
fracturing and things what our big fear

329
00:13:03,620 --> 00:13:01,770
on earth is that warm water in the ocean

330
00:13:05,810 --> 00:13:03,630
is getting underneath these ice shelves

331
00:13:07,370 --> 00:13:05,820
and destabilizing them and what we have

332
00:13:08,570 --> 00:13:07,380
to do is we have to get the topography

333
00:13:09,860 --> 00:13:08,580
of the under ice shelf we have to get

334
00:13:12,140 --> 00:13:09,870
the topography of the seafloor

335
00:13:14,840 --> 00:13:12,150
to understand how coastal waters mix in

336
00:13:16,550 --> 00:13:14,850
next slide but the last slide that I

337
00:13:18,890 --> 00:13:16,560
want to show you is actually a radar

338
00:13:20,270 --> 00:13:18,900

image over a sub glacial lake literally

339
00:13:21,259 --> 00:13:20,280
like one of these perch lakes we're

340
00:13:23,179 --> 00:13:21,269
talking about on your

341
00:13:25,699 --> 00:13:23,189
in Antarctica there are only over a

342
00:13:27,259 --> 00:13:25,709
hundred and forty of these lakes it's it

343
00:13:29,179 --> 00:13:27,269
was shocking to me I started working in

344
00:13:30,739 --> 00:13:29,189
the Antarctic world probably about seven

345
00:13:32,840 --> 00:13:30,749
or eight years ago we didn't really know

346
00:13:34,819 --> 00:13:32,850
there was that much water around and now

347
00:13:37,040 --> 00:13:34,829
to radar studies like this that vertical

348
00:13:38,869 --> 00:13:37,050
scale is about four kilometres and you

349
00:13:40,549 --> 00:13:38,879
see the flat line in the bottom that's

350
00:13:42,889 --> 00:13:40,559
where the radar waves have bounced off

351
00:13:45,590 --> 00:13:42,899
the surface of the lake that lake is the

352
00:13:47,030 --> 00:13:45,600
size of Lake Ontario and with that I'll

353
00:13:49,160 --> 00:13:47,040
pass off to Tori who's gonna tell us

354
00:13:50,989 --> 00:13:49,170
about habitability on Europa thanks Tom

355
00:13:52,970 --> 00:13:50,999
so one of the things that makes Europa

356
00:13:55,340 --> 00:13:52,980
so exciting that has made it such a

357
00:13:57,139 --> 00:13:55,350
compelling object of study for decades

358
00:13:59,540 --> 00:13:57,149
is the presence of this liquid water

359
00:14:00,889 --> 00:13:59,550
ocean that meets one of the critical

360
00:14:03,319 --> 00:14:00,899
requirements for life and what you're

361
00:14:05,239 --> 00:14:03,329
hearing about today from Brittany bears

362
00:14:06,799 --> 00:14:05,249
on a second of life crucial requirements

363
00:14:09,259 --> 00:14:06,809

and that is the requirement for energy

364
00:14:10,790 --> 00:14:09,269
so habitability is a concept that we all

365
00:14:12,889 --> 00:14:10,800
can relate to personal experience as

366
00:14:14,150 --> 00:14:12,899
living organisms anybody on the street

367
00:14:15,829 --> 00:14:14,160
could give you a pretty good accounting

368
00:14:19,309 --> 00:14:15,839
of what it takes to stay alive water

369
00:14:20,629 --> 00:14:19,319
food shelter air to breathe so if we

370
00:14:22,309 --> 00:14:20,639
think about these things in the context

371
00:14:24,169 --> 00:14:22,319
of Europa there is absolutely no

372
00:14:26,419 --> 00:14:24,179
shortage of water there that we know and

373
00:14:27,980 --> 00:14:26,429
have known for more than a decade as far

374
00:14:29,569 --> 00:14:27,990
as we know the environment is relatively

375
00:14:31,429 --> 00:14:29,579
sheltering if we think about shelter is

376
00:14:33,949 --> 00:14:31,439
the set of conditions that allow life to

377
00:14:35,480 --> 00:14:33,959
persist in an environmental context most

378
00:14:36,829 --> 00:14:35,490
of what we can see can conceive as a

379
00:14:39,530 --> 00:14:36,839
potential your open ocean chemistry

380
00:14:41,569 --> 00:14:39,540
would be reasonably suitable for life

381
00:14:42,980 --> 00:14:41,579
but the big an open question has been

382
00:14:45,049 --> 00:14:42,990
one of energy and when we talk about

383
00:14:46,280 --> 00:14:45,059
food to eat and air to breathe what

384
00:14:48,619 --> 00:14:46,290
we're really talking about is our

385
00:14:50,239 --> 00:14:48,629
requirement for energy and I've tried to

386
00:14:51,769 --> 00:14:50,249
conceptualize how to how to think of

387
00:14:53,629 --> 00:14:51,779
this in terms of a figure so you could

388
00:14:56,929 --> 00:14:53,639

view Europa as something like a great

389
00:14:58,429 --> 00:14:56,939
big battery it's stored energy and the

390
00:15:00,350 --> 00:14:58,439
question has been whether or not that

391
00:15:04,039 --> 00:15:00,360
stored energy is actually available for

392
00:15:06,109 --> 00:15:04,049
life on Europa so if you took a normal

393
00:15:07,730 --> 00:15:06,119
d-cell battery and cut it away what we

394
00:15:09,769 --> 00:15:07,740
would see is chemically different layers

395
00:15:11,569 --> 00:15:09,779
that are isolated from one another its

396
00:15:13,220 --> 00:15:11,579
energy that's stored and the way to tap

397
00:15:15,710 --> 00:15:13,230
that energy as you can see in the second

398
00:15:16,910 --> 00:15:15,720
slide is to connect the terminals when

399
00:15:18,919 --> 00:15:16,920
you connect the terminals with a wire

400
00:15:20,329 --> 00:15:18,929
electrons flow from place to place that

401
00:15:22,129 --> 00:15:20,339
flow of electrons is what we call

402
00:15:23,840 --> 00:15:22,139
electricity but in essence what's

403
00:15:25,789 --> 00:15:23,850
happening is a movement of material from

404
00:15:28,220 --> 00:15:25,799
the outer layer to the inner layer that

405
00:15:30,139 --> 00:15:28,230
serves to release energy so in the next

406
00:15:32,360 --> 00:15:30,149
slide you can see that we can view

407
00:15:34,220 --> 00:15:32,370
Europa in much the same way we know from

408
00:15:34,790 --> 00:15:34,230
spacecraft observations of surface

409
00:15:39,230 --> 00:15:34,800
chemistry

410
00:15:41,150 --> 00:15:39,240
Europa's crust that it represents in

411
00:15:43,880 --> 00:15:41,160
essence stored energy but with this big

412
00:15:45,650 --> 00:15:43,890
thick 10 kilometer or more I show the

413
00:15:47,240 --> 00:15:45,660

big open question has been does that

414
00:15:49,100 --> 00:15:47,250
energy ever get released is it ever

415
00:15:50,600 --> 00:15:49,110
available in the ocean what you're

416
00:15:52,730 --> 00:15:50,610
hearing about here today if we can have

417
00:15:54,949 --> 00:15:52,740
the last slide would be a way to take

418
00:15:56,630 --> 00:15:54,959
this surface material transport it

419
00:15:59,240 --> 00:15:56,640
potentially down into the ocean and in

420
00:16:00,829 --> 00:15:59,250
essence tap Europa's battery and you tap

421
00:16:02,300 --> 00:16:00,839
that battery you've moved from a system

422
00:16:04,550 --> 00:16:02,310
that checks one of the requirements for

423
00:16:06,199 --> 00:16:04,560
a life to a system that checks a second

424
00:16:07,670 --> 00:16:06,209
critical requirement for life and I

425
00:16:10,310 --> 00:16:07,680
think this really impacts the way that

426
00:16:11,360 --> 00:16:10,320
we consider habitability on Europa so

427
00:16:13,639 --> 00:16:11,370
how should we view this in the big

428
00:16:15,350 --> 00:16:13,649
context of your open ocean exploration I

429
00:16:18,410 --> 00:16:15,360
think Louise is the person to address

430
00:16:20,780 --> 00:16:18,420
this thank you sorry well this new model

431
00:16:22,400 --> 00:16:20,790
is very exciting in many respects

432
00:16:24,740 --> 00:16:22,410
because it ties together a lot of loose

433
00:16:27,319 --> 00:16:24,750
ends from Europa studies that have

434
00:16:31,030 --> 00:16:27,329
spanned most the last decade here in the

435
00:16:33,680 --> 00:16:31,040
first slide I am showing a figure that

436
00:16:36,319 --> 00:16:33,690
represents two previous models for

437
00:16:38,960 --> 00:16:36,329
Europa's shell the one on the left shows

438
00:16:40,579 --> 00:16:38,970

the ocean and the ice shell the total

439
00:16:42,650 --> 00:16:40,589
thickness of this is about 150

440
00:16:44,500 --> 00:16:42,660
kilometers but here the shell is

441
00:16:47,449 --> 00:16:44,510
depicted as being very thin maybe only

442
00:16:50,420 --> 00:16:47,459
five kilometers or less and the plumes

443
00:16:52,460 --> 00:16:50,430
that you're seeing here would be in the

444
00:16:54,769 --> 00:16:52,470
ocean there hydrothermal plumes from the

445
00:16:57,319 --> 00:16:54,779
floor from where the ocean floor meets

446
00:16:59,900 --> 00:16:57,329
the mantle of Europa on the right hand

447
00:17:02,180 --> 00:16:59,910
side is a depiction of a thicker shell

448
00:17:04,730 --> 00:17:02,190
model where the shell here would be

449
00:17:07,850 --> 00:17:04,740
about 15 to 30 kilometers it's not quite

450
00:17:09,169 --> 00:17:07,860
to scale but the underlying plumes from

451
00:17:11,210 --> 00:17:09,179
the ocean floor would impinge on the

452
00:17:13,760 --> 00:17:11,220
bottom of the ice shell and would warm

453
00:17:15,949 --> 00:17:13,770
it and as such would create plumes

454
00:17:18,650 --> 00:17:15,959
within the shell these are convective

455
00:17:20,090 --> 00:17:18,660
plumes so it's actually solid material

456
00:17:21,710 --> 00:17:20,100
that is mobilized because it's slightly

457
00:17:23,510 --> 00:17:21,720
warmer than their surroundings so

458
00:17:26,120 --> 00:17:23,520
similar to what you would see in a

459
00:17:28,130 --> 00:17:26,130
saucepan of bubbling soup I'm told me so

460
00:17:30,020 --> 00:17:28,140
soup does this very well but you can see

461
00:17:32,150 --> 00:17:30,030
different convection cells and material

462
00:17:34,340 --> 00:17:32,160
moves upwards in the center and down at

463
00:17:36,860 --> 00:17:34,350

the margins and these two models have

464
00:17:38,360 --> 00:17:36,870
been used to explain some of the

465
00:17:41,270 --> 00:17:38,370
observations we've seen on the surface

466
00:17:43,220 --> 00:17:41,280
of Europa but neither of them have been

467
00:17:43,730 --> 00:17:43,230
able to explain everything we see and

468
00:17:46,070 --> 00:17:43,740
that's been

469
00:17:47,330 --> 00:17:46,080
big problem for us but with a new model

470
00:17:49,190 --> 00:17:47,340
that Brittany and her colleagues have

471
00:17:51,560 --> 00:17:49,200
put together we can now explain pretty

472
00:17:54,350 --> 00:17:51,570
much every geological observation that

473
00:17:56,330 --> 00:17:54,360
we see surrounding chaos on Europa so

474
00:17:57,530 --> 00:17:56,340
it's really sort of come along and and

475
00:18:00,530 --> 00:17:57,540
joined together

476
00:18:03,320 --> 00:18:00,540
a lot of dots so we're very happy to see

477
00:18:06,950 --> 00:18:03,330
that next I want to talk about the

478
00:18:09,740 --> 00:18:06,960
distribution of chaos and its age if you

479
00:18:11,960 --> 00:18:09,750
look at this image of Europa you can see

480
00:18:14,540 --> 00:18:11,970
that the surface looks very different

481
00:18:17,060 --> 00:18:14,550
from say the surface of the Moon or

482
00:18:18,860 --> 00:18:17,070
mercury those bodies are very heavily

483
00:18:20,870 --> 00:18:18,870
impact crater they've got a lot of

484
00:18:23,630 --> 00:18:20,880
cratering scars on them

485
00:18:24,980 --> 00:18:23,640
whereas Europa you can see has hardly

486
00:18:27,440 --> 00:18:24,990
any in fact I'm not sure you can even

487
00:18:28,910 --> 00:18:27,450
make any out of this scale now we use

488
00:18:31,010 --> 00:18:28,920

the number of impact craters on the

489
00:18:33,560 --> 00:18:31,020
surface of the body as a proxy for age

490
00:18:35,240 --> 00:18:33,570
we assume that things like comets and

491
00:18:37,669 --> 00:18:35,250
meteorites that are coming into a system

492
00:18:40,340 --> 00:18:37,679
impact the surface on a fairly constant

493
00:18:41,600 --> 00:18:40,350
basis and so if something has a lot of

494
00:18:43,669 --> 00:18:41,610
them that means that it's been sitting

495
00:18:45,380 --> 00:18:43,679
there getting this weathering process

496
00:18:46,910 --> 00:18:45,390
for a very long time whereas if

497
00:18:48,830 --> 00:18:46,920
something doesn't have many craters it's

498
00:18:51,320 --> 00:18:48,840
probably very young and in the case of

499
00:18:54,740 --> 00:18:51,330
Europa something has happened to erase

500
00:18:56,840 --> 00:18:54,750
the impact scars from the surface and in

501
00:18:59,360 --> 00:18:56,850
this case it could be tectonic features

502
00:19:01,549 --> 00:18:59,370
so faults and fractures on the surface

503
00:19:03,410 --> 00:19:01,559
that could erase whatever has come

504
00:19:05,180 --> 00:19:03,420
before it could be some kind of cryo

505
00:19:07,160 --> 00:19:05,190
volcanism and it certainly could be

506
00:19:09,770 --> 00:19:07,170
chaos so if we can start the movie

507
00:19:11,960 --> 00:19:09,780
please and in fact the average age of

508
00:19:14,330 --> 00:19:11,970
Europa is thought to only be about 60

509
00:19:16,010 --> 00:19:14,340
million years now on human timescales

510
00:19:17,870 --> 00:19:16,020
that's a very long time but in

511
00:19:19,490 --> 00:19:17,880
geological timescales that's the blink

512
00:19:22,340 --> 00:19:19,500
of an eye it was almost born yesterday

513
00:19:25,640 --> 00:19:22,350

on the surface so Europa already has a

514
00:19:28,490 --> 00:19:25,650
very young surface age and here we're

515
00:19:31,190 --> 00:19:28,500
zooming into sera macula on the Left

516
00:19:33,799 --> 00:19:31,200
which Britney talked about earlier and a

517
00:19:34,940 --> 00:19:33,809
chaos very close to it Thrace macula on

518
00:19:35,750 --> 00:19:34,950
the right as you can see they're both

519
00:19:38,419 --> 00:19:35,760
quite large

520
00:19:41,419 --> 00:19:38,429
Sarah is about 80 kilometers maybe a

521
00:19:42,890 --> 00:19:41,429
little over 50 miles across and notice

522
00:19:44,570 --> 00:19:42,900
that these are very different from their

523
00:19:47,419 --> 00:19:44,580
surroundings are both very dark

524
00:19:48,919 --> 00:19:47,429
they have unusual scalloped margins as

525
00:19:51,169 --> 00:19:48,929
they don't look like a lot of the long

526
00:19:53,419 --> 00:19:51,179
linear features that we see that appear

527
00:19:54,890 --> 00:19:53,429
to be faults and fractures these two

528
00:19:57,140 --> 00:19:54,900
arrows are pointing towards a

529
00:20:00,140 --> 00:19:57,150
semicircular Frank

530
00:20:01,460 --> 00:20:00,150
system that was once intact we're

531
00:20:03,560 --> 00:20:01,470
looking at the two sides in it and you

532
00:20:06,049 --> 00:20:03,570
can see that Thrace macula on the right

533
00:20:08,420 --> 00:20:06,059
has actually disrupted the middle of

534
00:20:10,340 --> 00:20:08,430
that is completely destroyed in fact and

535
00:20:12,590 --> 00:20:10,350
so this shows that this chaos region

536
00:20:14,630 --> 00:20:12,600
over lies those tectonic features and so

537
00:20:17,210 --> 00:20:14,640
it's much younger so what we're showing

538
00:20:20,090 --> 00:20:17,220

here is not only is Europa's surface

539
00:20:22,580 --> 00:20:20,100
young but chaos is very young still and

540
00:20:24,740 --> 00:20:22,590
in fact it's one of the youngest future

541
00:20:27,020 --> 00:20:24,750
types is not the major young land form

542
00:20:29,570 --> 00:20:27,030
on the surface so it's very very young

543
00:20:33,380 --> 00:20:29,580
here I'm just zooming out showing you

544
00:20:35,299 --> 00:20:33,390
the equator there's a big X just off the

545
00:20:36,919 --> 00:20:35,309
center to the left just as the south of

546
00:20:38,630 --> 00:20:36,929
that is connemara chaos which Britney

547
00:20:40,940 --> 00:20:38,640
also mentioned earlier you can see all

548
00:20:43,250 --> 00:20:40,950
this brown mottled material over the

549
00:20:46,370 --> 00:20:43,260
surface all of that is chaos terrain

550
00:20:49,190 --> 00:20:46,380
it's very widespread in fact we think

551
00:20:50,930 --> 00:20:49,200
you know estimates vary because we don't

552
00:20:52,430 --> 00:20:50,940
have particularly good imaging data of

553
00:20:54,590 --> 00:20:52,440
much of Europa but we think it could be

554
00:20:56,990 --> 00:20:54,600
as much as 50 percent of the surface has

555
00:20:59,690 --> 00:20:57,000
been completely destroyed in recent eyes

556
00:21:02,240 --> 00:20:59,700
by this chaos formation and so to

557
00:21:03,919 --> 00:21:02,250
summarize this is very important result

558
00:21:05,780 --> 00:21:03,929
because first of all it draws together

559
00:21:09,290 --> 00:21:05,790
many of the conflicting observations

560
00:21:10,640 --> 00:21:09,300
that we've seen in the last 10 years but

561
00:21:13,850 --> 00:21:10,650
secondly it shows that there could be

562
00:21:16,910 --> 00:21:13,860
these huge hidden lakes in Europa's

563
00:21:19,100 --> 00:21:16,920

shale widespread bodies of water may be

564
00:21:22,640 --> 00:21:19,110
taking up as much as half of the upper

565
00:21:24,680 --> 00:21:22,650
shell of Europa and so chaos regions are

566
00:21:26,660 --> 00:21:24,690
going to be extremely important as

567
00:21:28,910 --> 00:21:26,670
possible future targets for exploration

568
00:21:30,980 --> 00:21:28,920
and with that I'll pass back toward

569
00:21:32,810 --> 00:21:30,990
Wayne thank you thank you all so um what

570
00:21:34,130 --> 00:21:32,820
we're gonna do is we're gonna start here

571
00:21:35,690 --> 00:21:34,140
with a question and if you can wait for

572
00:21:38,299 --> 00:21:35,700
the microphone and give your name and

573
00:21:41,480 --> 00:21:38,309
affiliation and then we'll go to the

574
00:21:43,190 --> 00:21:41,490
phone lines randy Shostak reported with

575
00:21:45,169 --> 00:21:43,200
AOS newspaper of the american

576
00:21:46,910 --> 00:21:45,179
geophysical union this is very

577
00:21:48,830 --> 00:21:46,920
interesting information and some I guess

578
00:21:51,020 --> 00:21:48,840
I have sort of a basic question I'd

579
00:21:55,040 --> 00:21:51,030
appreciate if you could describe further

580
00:21:58,580 --> 00:21:55,050
the other models that you investigated

581
00:22:00,500 --> 00:21:58,590
and explored and perhaps discarded what

582
00:22:02,930 --> 00:22:00,510
are the weaknesses in those models for

583
00:22:04,520 --> 00:22:02,940
describing europa and do you believe

584
00:22:08,480 --> 00:22:04,530
that the model that you've outlined

585
00:22:10,060 --> 00:22:08,490
today is the only model that now is

586
00:22:12,340 --> 00:22:10,070
useful in this

587
00:22:14,320 --> 00:22:12,350
in Europa sufficiently or could there

588
00:22:19,870 --> 00:22:14,330

potentially be other models that might

589
00:22:22,600 --> 00:22:19,880
be useful here for a long time we've

590
00:22:25,450 --> 00:22:22,610
thought that Kaos terrain is formed in

591
00:22:28,390 --> 00:22:25,460
the presence of some amount of water one

592
00:22:30,760 --> 00:22:28,400
of the key unknowns is how you get those

593
00:22:33,160 --> 00:22:30,770
surfaces like connemara chaos to

594
00:22:35,770 --> 00:22:33,170
actually produce domes up above the

595
00:22:38,710 --> 00:22:35,780
surface it's actually very hard to do

596
00:22:40,480 --> 00:22:38,720
with most models there have been a

597
00:22:42,370 --> 00:22:40,490
couple of models suggested at all highly

598
00:22:46,000 --> 00:22:42,380
two of them one is that you completely

599
00:22:48,040 --> 00:22:46,010
melt the ice shell and that that the

600
00:22:50,410 --> 00:22:48,050
matrix material represents places where

601
00:22:52,240 --> 00:22:50,420
liquid water flowed on the surface that

602
00:22:54,100 --> 00:22:52,250
has some problems just because of the

603
00:22:56,170 --> 00:22:54,110
cold surface temperatures of Europa and

604
00:22:57,850 --> 00:22:56,180
because other observations of Europa

605
00:23:00,670 --> 00:22:57,860
suggest that the shell is incredibly

606
00:23:03,430 --> 00:23:00,680
thick on the other hand there's been

607
00:23:06,310 --> 00:23:03,440
models of convection and diapir ISM

608
00:23:09,430 --> 00:23:06,320
where the goal was to try to look at if

609
00:23:12,460 --> 00:23:09,440
plumes could survive up into the surface

610
00:23:14,710 --> 00:23:12,470
ice - cause that doming well if you

611
00:23:17,020 --> 00:23:14,720
relaxed that constraint and think about

612
00:23:20,110 --> 00:23:17,030
what happens when ice actually gets

613
00:23:22,840 --> 00:23:20,120

heated is it melts and so in fact the

614
00:23:26,110 --> 00:23:22,850
opposite of what what was the goal

615
00:23:27,940 --> 00:23:26,120
happens and that as the ice melts it

616
00:23:30,340 --> 00:23:27,950
contracts and causes the surface to

617
00:23:32,380 --> 00:23:30,350
depress but what that also does is it

618
00:23:34,660 --> 00:23:32,390
gives a chance for the surface to break

619
00:23:36,760 --> 00:23:34,670
up to fracture just like ice shelves on

620
00:23:38,740 --> 00:23:36,770
the earth why that's important is that

621
00:23:41,730 --> 00:23:38,750
we see icebergs on Europa

622
00:23:44,020 --> 00:23:41,740
seem to follow pre-existing lines

623
00:23:45,310 --> 00:23:44,030
fractures that already existed so it's

624
00:23:47,260 --> 00:23:45,320
like it's being opened up from the

625
00:23:49,600 --> 00:23:47,270
bottom water is getting in there and

626
00:23:51,520 --> 00:23:49,610
breaking off those chunks of ice when

627
00:23:53,230 --> 00:23:51,530
you do that you've mixed up all the

628
00:23:56,020 --> 00:23:53,240
other stuff we mentioned a mosh pit of

629
00:23:58,390 --> 00:23:56,030
ice earlier as those big strong icebergs

630
00:24:00,640 --> 00:23:58,400
move around they can break up all of the

631
00:24:03,070 --> 00:24:00,650
weak ice in between which can fill with

632
00:24:05,860 --> 00:24:03,080
water still not be liquid but fill with

633
00:24:08,050 --> 00:24:05,870
water as you freeze that out the

634
00:24:10,300 --> 00:24:08,060
expansion happens again so just as the

635
00:24:12,670 --> 00:24:10,310
ice when it melted caused thermal

636
00:24:15,130 --> 00:24:12,680
contraction when it refreezes it causes

637
00:24:17,140 --> 00:24:15,140
thermal expansion and that gives you the

638
00:24:19,180 --> 00:24:17,150

extra boost needed to kind of pop that

639
00:24:22,990 --> 00:24:19,190
surface back up into a dome because

640
00:24:23,560 --> 00:24:23,000
you've entrained salt rich water into

641
00:24:28,270 --> 00:24:23,570
that

642
00:24:30,280 --> 00:24:28,280
texture on the surface so it's not the

643
00:24:32,560 --> 00:24:30,290
only model that's out there but one of

644
00:24:35,500 --> 00:24:32,570
the exciting things about it is that it

645
00:24:37,780 --> 00:24:35,510
does kind of explain why we see icebergs

646
00:24:39,360 --> 00:24:37,790
which might seem to think seem to make

647
00:24:42,370 --> 00:24:39,370
you think that the ice shell is thin but

648
00:24:46,170 --> 00:24:42,380
also this matrix material in these domes

649
00:24:51,090 --> 00:24:49,690
okay let's go to the phone lines and

650
00:24:53,710 --> 00:24:51,100
we're gonna head out to the west coast

651
00:24:59,230 --> 00:24:53,720
with David Pearlman from the San

652
00:25:04,570 --> 00:24:59,240
Francisco Chronicle David hey thank you

653
00:25:07,570 --> 00:25:04,580
very much just two questions quickly one

654
00:25:10,090 --> 00:25:07,580
is a NASA seems to have placed a

655
00:25:13,690 --> 00:25:10,100
priority in the search for lights on

656
00:25:18,250 --> 00:25:13,700
life on these Jovian moons and others

657
00:25:20,890 --> 00:25:18,260
and Enceladus and Titan seem to be the

658
00:25:24,460 --> 00:25:20,900
higher priority targets are you people

659
00:25:28,540 --> 00:25:24,470
making a pitch for more attention being

660
00:25:32,910 --> 00:25:28,550
paid to Europa and if so how do you make

661
00:25:36,940 --> 00:25:32,920
that pitch besides a forum like this and

662
00:25:40,210 --> 00:25:36,950
incidentally is this theory about chaos

663
00:25:44,080 --> 00:25:40,220

terrain being published or has it been

664
00:25:48,670 --> 00:25:44,090
published in the literature and I'll

665
00:25:50,740 --> 00:25:48,680
take the answer right now I think what

666
00:25:53,170 --> 00:25:50,750
we're saying is that Europa continues to

667
00:25:56,320 --> 00:25:53,180
be an interesting priority for

668
00:26:00,010 --> 00:25:56,330
exploration which it has been for for 30

669
00:26:02,680 --> 00:26:00,020
years or more yes the the paper has been

670
00:26:05,530 --> 00:26:02,690
published it was just released advanced

671
00:26:08,350 --> 00:26:05,540
online publication by Nature today and

672
00:26:12,100 --> 00:26:08,360
will appear in the print version of the

673
00:26:17,320 --> 00:26:12,110
magazine next week can I just add to

674
00:26:20,340 --> 00:26:17,330
that the the National Academy of

675
00:26:23,440 --> 00:26:20,350
Sciences published a decadal survey for

676
00:26:25,660 --> 00:26:23,450
exploration which was the science

677
00:26:27,820 --> 00:26:25,670
community giving NASA its suggested

678
00:26:29,810 --> 00:26:27,830
priorities for exploration of the next

679
00:26:31,190 --> 00:26:29,820
and I was actually part of the

680
00:26:33,230 --> 00:26:31,200
satellites panel that looks at both

681
00:26:35,390 --> 00:26:33,240
Titan and Europa and they are both

682
00:26:37,790 --> 00:26:35,400
considered to be extremely important

683
00:26:39,950 --> 00:26:37,800
targets and both have astrobiological

684
00:26:42,470 --> 00:26:39,960
potential for different reasons

685
00:26:45,530 --> 00:26:42,480
but at this time that panel felt that

686
00:26:48,080 --> 00:26:45,540
Europa was more compelling and partly

687
00:26:50,540 --> 00:26:48,090
because Titan does need some technology

688
00:26:52,520 --> 00:26:50,550

development to do certain types of

689
00:26:54,710 --> 00:26:52,530
missions there so they are both very

690
00:26:56,090 --> 00:26:54,720
important targets but at this time it

691
00:26:57,770 --> 00:26:56,100
was felt that you know the

692
00:27:02,000 --> 00:26:57,780
recommendation from that panel was that

693
00:27:06,620 --> 00:27:02,010
Patsy Roper was of a higher priority at

694
00:27:08,650 --> 00:27:06,630
the moment okay I actually have two

695
00:27:10,820 --> 00:27:08,660
questions here the first one is for

696
00:27:13,490 --> 00:27:10,830
Brittany from one of the dot-coms and

697
00:27:15,770 --> 00:27:13,500
then for Tom Wagner so the question is

698
00:27:18,170 --> 00:27:15,780
very simple what are the next steps with

699
00:27:20,900 --> 00:27:18,180
presenting this in the data that you

700
00:27:24,970 --> 00:27:20,910
have now I'm glad to answer that

701
00:27:27,560 --> 00:27:24,980
question for us the next steps with

702
00:27:29,060 --> 00:27:27,570
understanding chaos formation and

703
00:27:31,850 --> 00:27:29,070
whether this Lake model really is

704
00:27:35,690 --> 00:27:31,860
correct is to look at the entire surface

705
00:27:38,690 --> 00:27:35,700
there's still data to be used in the

706
00:27:41,210 --> 00:27:38,700
Galileo archives that we can use to

707
00:27:44,270 --> 00:27:41,220
compare this model to other models and

708
00:27:46,100 --> 00:27:44,280
really rigorously test it and then and

709
00:27:47,870 --> 00:27:46,110
then we'll be ready to go on and test

710
00:27:54,610 --> 00:27:47,880
hypotheses in the future with

711
00:27:56,570 --> 00:27:54,620
exploration as the earth scientists

712
00:27:58,700 --> 00:27:56,580
personally what are your feelings on

713
00:28:00,920 --> 00:27:58,710

what you're seeing here how it relates

714
00:28:02,540 --> 00:28:00,930
to your research I think it's fantastic

715
00:28:04,370 --> 00:28:02,550
you know we don't have that many of

716
00:28:06,080 --> 00:28:04,380
these examples even on the earth of ice

717
00:28:08,030 --> 00:28:06,090
shelves collapsing so anytime we can go

718
00:28:09,500 --> 00:28:08,040
and see something like this and also the

719
00:28:10,550 --> 00:28:09,510
scale is tremendous you know that's one

720
00:28:12,710 --> 00:28:10,560
of the things the Europa scale is a

721
00:28:14,150 --> 00:28:12,720
little bit bigger but that in the future

722
00:28:14,750 --> 00:28:14,160
may be something that's more relevant to

723
00:28:16,220 --> 00:28:14,760
us here on earth

724
00:28:17,750 --> 00:28:16,230
so I think it's an exciting research

725
00:28:19,850 --> 00:28:17,760
example for us to continue to work

726
00:28:23,150 --> 00:28:19,860
together on we have any other questions

727
00:28:25,010 --> 00:28:23,160
here good I guess I'd just like to

728
00:28:27,770 --> 00:28:25,020
follow up on that last question that was

729
00:28:29,270 --> 00:28:27,780
asked in your response during your

730
00:28:32,270 --> 00:28:29,280
presentation and talked a lot about what

731
00:28:33,920 --> 00:28:32,280
the earth might help us to how the earth

732
00:28:35,450 --> 00:28:33,930
might help us to understand Europa if

733
00:28:37,160 --> 00:28:35,460
you can elaborate a little bit more on

734
00:28:39,740 --> 00:28:37,170
how Europa might help us to understand

735
00:28:41,360 --> 00:28:39,750
more about Earth processes yeah sure you

736
00:28:42,710 --> 00:28:41,370
know one of the big things is

737
00:28:44,420 --> 00:28:42,720
we're kind of in a new state on the

738
00:28:48,020 --> 00:28:44,430

planet you know and when we try to

739
00:28:49,549 --> 00:28:48,030
understand say the Pine Island area we

740
00:28:51,350 --> 00:28:49,559
try to understand that large large large

741
00:28:53,990 --> 00:28:51,360
ice shelf and how it's going to interact

742
00:28:55,940 --> 00:28:54,000
with the art with the ocean how one of

743
00:28:58,970 --> 00:28:55,950
the theories right now is this that

744
00:29:01,400 --> 00:28:58,980
you've got lack of sea ice and anomalous

745
00:29:03,230 --> 00:29:01,410
winds blowing warm water up onto the

746
00:29:05,810 --> 00:29:03,240
continental shelf around Antarctica and

747
00:29:06,980 --> 00:29:05,820
that's causing the ice shelves to thin

748
00:29:09,230 --> 00:29:06,990
and that's causing something to

749
00:29:10,580 --> 00:29:09,240
destabilize and breakup well we've seen

750
00:29:12,470 --> 00:29:10,590
that happen but we've only seen it

751
00:29:14,150 --> 00:29:12,480
happen right now in kind of small places

752
00:29:16,040 --> 00:29:14,160
around the fringe how is it gonna happen

753
00:29:18,140 --> 00:29:16,050
in bigger places you know what's gonna

754
00:29:20,330 --> 00:29:18,150
happen is that warm water gets in deeper

755
00:29:21,380 --> 00:29:20,340
and said something that we're gonna get

756
00:29:23,660 --> 00:29:21,390
are just simple things even like

757
00:29:25,040 --> 00:29:23,670
geometric constraints right like you

758
00:29:27,140 --> 00:29:25,050
know what's gonna happen to a really

759
00:29:29,030 --> 00:29:27,150
thick area as it breaks up and something

760
00:29:30,650 --> 00:29:29,040
that I didn't talk that much about the

761
00:29:32,419 --> 00:29:30,660
Wilkins Ice Shelf that I showed first

762
00:29:33,590 --> 00:29:32,429
the reason for show that's so

763
00:29:35,960 --> 00:29:33,600

interesting is that it was kind of

764
00:29:37,700 --> 00:29:35,970
mechanical breakup in that the ice shelf

765
00:29:38,720 --> 00:29:37,710
had flowed out and as it flows out in

766
00:29:40,490 --> 00:29:38,730
the ocean and gets thinner and thinner

767
00:29:41,960 --> 00:29:40,500
and thinner just like I say picture it

768
00:29:43,760 --> 00:29:41,970
like spreading pancake batter you know

769
00:29:45,230 --> 00:29:43,770
it just gets thinner as it goes out and

770
00:29:47,660 --> 00:29:45,240
then eventually destabilizes and breaks

771
00:29:49,370 --> 00:29:47,670
up and it triggers with the larsen ice

772
00:29:50,900 --> 00:29:49,380
shelf case one of the theories is that

773
00:29:52,669 --> 00:29:50,910
you had surface melting so you had

774
00:29:54,650 --> 00:29:52,679
warming of the surrounding area of water

775
00:29:56,000 --> 00:29:54,660
form and then kind of like the Europa

776
00:29:58,760 --> 00:29:56,010
example except kind of in the reverse

777
00:30:00,760 --> 00:29:58,770
way that water percolated down forced

778
00:30:02,660 --> 00:30:00,770
its way through cracks created cracks

779
00:30:04,760 --> 00:30:02,670
destabilize the ice shelf and it could

780
00:30:05,900 --> 00:30:04,770
break apart along those things so

781
00:30:07,700 --> 00:30:05,910
there's you know those are kind of two

782
00:30:09,350 --> 00:30:07,710
end member cases that we're trying to

783
00:30:12,710 --> 00:30:09,360
test between and Europe is now another

784
00:30:15,049 --> 00:30:12,720
example for us to think about okay what

785
00:30:17,600 --> 00:30:15,059
we're gonna do is actually they've done

786
00:30:18,830 --> 00:30:17,610
such a great job explaining that we have

787
00:30:20,780 --> 00:30:18,840
no further questions on the line

788
00:30:22,160 --> 00:30:20,790

although we have numerous media that are

789
00:30:24,950 --> 00:30:22,170
listening in so I want to thank you all

790
00:30:30,140 --> 00:30:24,960
for joining us obviously information go