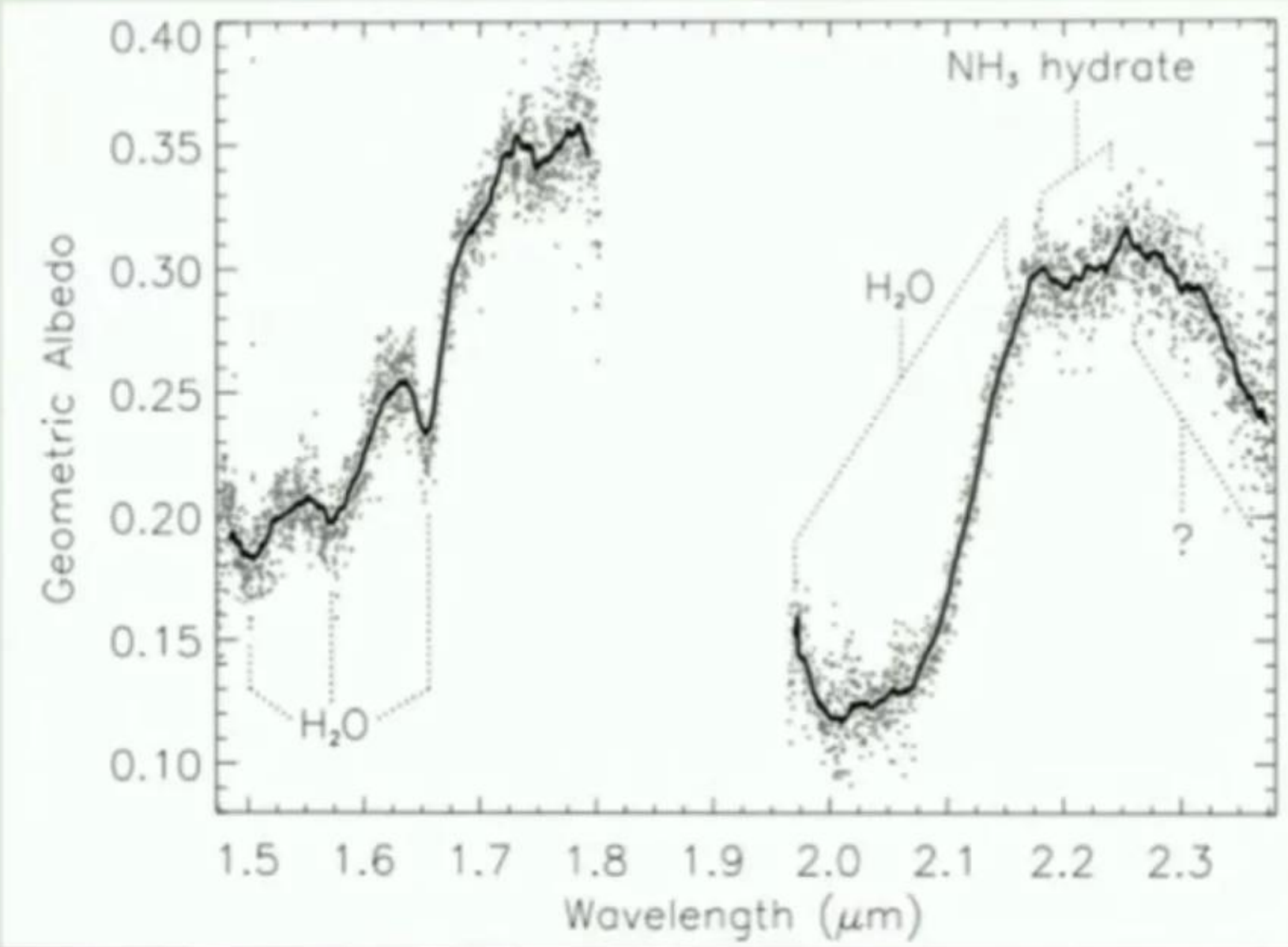
Charon's NIR spectrum



1
00:00:02,140 --> 00:00:06,710
[Music]

2
00:00:10,150 --> 00:00:08,230
i'm brian holler

3
00:00:11,270 --> 00:00:10,160
i am a starting my fifth year grad

4
00:00:13,270 --> 00:00:11,280
school

5
00:00:15,190 --> 00:00:13,280
here at the university of colorado in

6
00:00:16,790 --> 00:00:15,200
the aps department so

7
00:00:18,710 --> 00:00:16,800
astronomy and or astrophysics and

8
00:00:20,070 --> 00:00:18,720
planetary science i work with leslie

9
00:00:21,990 --> 00:00:20,080
young at the southwest research

10
00:00:23,910 --> 00:00:22,000
institute

11
00:00:26,710 --> 00:00:23,920
she's a deputy project scientist on new

12
00:00:29,109 --> 00:00:26,720
horizons um i will not be presenting new

13
00:00:30,470 --> 00:00:29,119

horizons data i'm not on the mission

14
00:00:33,190 --> 00:00:30,480
i'll be presenting

15
00:00:35,910 --> 00:00:33,200
um ground-based observations of sharon

16
00:00:38,630 --> 00:00:35,920
uh which are pretty hard to come by um

17
00:00:40,709 --> 00:00:38,640
and this picture is a combination of

18
00:00:42,470 --> 00:00:40,719
pluto and sharon

19
00:00:43,990 --> 00:00:42,480
yin yang pattern

20
00:00:45,510 --> 00:00:44,000
showing that they're you know two sides

21
00:00:46,869 --> 00:00:45,520
of the same

22
00:00:49,270 --> 00:00:46,879
thing

23
00:00:52,709 --> 00:00:49,280
they're very different but uh

24
00:00:56,150 --> 00:00:54,950
so a little overview of what i'll be

25
00:00:58,069 --> 00:00:56,160
talking about

26
00:00:59,189 --> 00:00:58,079
sharon is the largest moon of pluto but

27
00:01:01,830 --> 00:00:59,199
they have very different surface

28
00:01:04,229 --> 00:01:01,840
compositions sharon is uh primarily

29
00:01:05,429 --> 00:01:04,239
covered in water ice in both crystalline

30
00:01:06,390 --> 00:01:05,439
and amorphous

31
00:01:08,710 --> 00:01:06,400
phase

32
00:01:11,270 --> 00:01:08,720
as well as ammonia hydrate

33
00:01:12,550 --> 00:01:11,280
pluto is covered in relatively volatile

34
00:01:14,469 --> 00:01:12,560
ices

35
00:01:17,830 --> 00:01:14,479
molecular nitrogen

36
00:01:19,510 --> 00:01:17,840
methane and carbon monoxide

37
00:01:21,030 --> 00:01:19,520
and it took the new horizons mission to

38
00:01:22,550 --> 00:01:21,040

actually detect water on the surface

39
00:01:25,109 --> 00:01:22,560
it's never been detected in ground-based

40
00:01:26,469 --> 00:01:25,119
spectra on pluto

41
00:01:27,590 --> 00:01:26,479
it's one of only two objects in the

42
00:01:29,350 --> 00:01:27,600
kuiper belt

43
00:01:32,789 --> 00:01:29,360
uh where ammonia has been detected the

44
00:01:36,630 --> 00:01:34,710
the high crystalline water ice fraction

45
00:01:38,390 --> 00:01:36,640
is kind of strange

46
00:01:40,630 --> 00:01:38,400
on charon

47
00:01:42,069 --> 00:01:40,640
we'd expect so crystalline water ice is

48
00:01:44,069 --> 00:01:42,079
the kind of ice that you find on earth

49
00:01:46,069 --> 00:01:44,079
primarily you know in your ice cube it's

50
00:01:47,990 --> 00:01:46,079
well ordered crystalline matrix

51
00:01:50,469 --> 00:01:48,000
uh when it interacts with radiation or

52
00:01:52,069 --> 00:01:50,479
cosmic rays uh those bonds break and you

53
00:01:53,270 --> 00:01:52,079
get an amorphous solid sort of like

54
00:01:54,870 --> 00:01:53,280
glass

55
00:01:57,109 --> 00:01:54,880
where there's randomly oriented

56
00:01:58,950 --> 00:01:57,119
molecules in the solid

57
00:02:00,310 --> 00:01:58,960
so you expect over time you lose the

58
00:02:02,069 --> 00:02:00,320
crystalline water ice you gain more

59
00:02:03,510 --> 00:02:02,079
amorphous water ice

60
00:02:05,429 --> 00:02:03,520
that doesn't appear to be the case on

61
00:02:07,429 --> 00:02:05,439
cheron

62
00:02:09,749 --> 00:02:07,439
we also you know because we detect

63
00:02:11,430 --> 00:02:09,759

ammonia on the surface

64
00:02:13,110 --> 00:02:11,440
as well as crystalline water ace has

65
00:02:13,910 --> 00:02:13,120
been put forward that there's some sort

66
00:02:15,430 --> 00:02:13,920
of

67
00:02:17,190 --> 00:02:15,440
um

68
00:02:20,790 --> 00:02:17,200
resurfacing mechanism such as

69
00:02:22,710 --> 00:02:20,800
cryovolcanism going on on cheron

70
00:02:24,630 --> 00:02:22,720
now i'm here to tell you that i think we

71
00:02:26,150 --> 00:02:24,640
don't need cryovolcanism

72
00:02:27,190 --> 00:02:26,160
it can be explained

73
00:02:30,229 --> 00:02:27,200
uh

74
00:02:32,470 --> 00:02:30,239
other ways um so sharon

75
00:02:34,630 --> 00:02:32,480
is not active and i apologize to mark

76
00:02:37,190 --> 00:02:34,640
who's going in two talks from now

77
00:02:38,229 --> 00:02:37,200
based on his talk title it seems like

78
00:02:43,190 --> 00:02:38,239
he's going to be talking about how

79
00:02:48,470 --> 00:02:45,190
so sharon and pluto

80
00:02:51,750 --> 00:02:50,790
giant impact say a proto pluto proto

81
00:02:53,589 --> 00:02:51,760
cheron

82
00:02:55,030 --> 00:02:53,599
you have a grazing collision that

83
00:02:56,790 --> 00:02:55,040
results in

84
00:02:58,790 --> 00:02:56,800
the formation of the system we see today

85
00:03:02,149 --> 00:02:58,800
which has five moons four of them are

86
00:03:03,990 --> 00:03:02,159
tiny likely formed from a debris disk of

87
00:03:05,430 --> 00:03:04,000
ice

88
00:03:07,830 --> 00:03:05,440

after the formation of the other two

89
00:03:09,430 --> 00:03:07,840
objects

90
00:03:11,110 --> 00:03:09,440
but after this point in time they have

91
00:03:12,550 --> 00:03:11,120
followed very different evolutionary

92
00:03:14,229 --> 00:03:12,560
paths

93
00:03:16,309 --> 00:03:14,239
even though they share the same orbit

94
00:03:17,430 --> 00:03:16,319
same radiation environment

95
00:03:21,030 --> 00:03:17,440
they have very different surface

96
00:03:23,110 --> 00:03:21,040
compositions very different histories

97
00:03:25,430 --> 00:03:23,120
so when i was looking at all the talks

98
00:03:26,550 --> 00:03:25,440
uh i saw people were probably going to

99
00:03:28,470 --> 00:03:26,560
talk about how they went to really cool

100
00:03:30,630 --> 00:03:28,480
places so i felt like i needed to

101
00:03:33,509 --> 00:03:30,640
represent the observational astronomers

102
00:03:34,949 --> 00:03:33,519
i went to hawaii last year for 50 days

103
00:03:38,390 --> 00:03:34,959
to get all this data

104
00:03:42,070 --> 00:03:41,190
to obtain this data

105
00:03:44,149 --> 00:03:42,080
and

106
00:03:48,149 --> 00:03:44,159
one of the nights i was there

107
00:03:52,789 --> 00:03:50,470
and that was the date of the closest

108
00:03:54,949 --> 00:03:52,799
approach of new horizons to pluto

109
00:03:56,470 --> 00:03:54,959
uh the image up there

110
00:03:58,710 --> 00:03:56,480
was the data that i was taking at the

111
00:04:00,789 --> 00:03:58,720
exact moment of the flyby

112
00:04:03,750 --> 00:04:00,799
the rotation period of charon is in

113
00:04:05,509 --> 00:04:03,760

pluto about 6.4 days so the four hour

114
00:04:07,589 --> 00:04:05,519
time difference or you know the light

115
00:04:09,750 --> 00:04:07,599
travel time didn't really make much of a

116
00:04:12,229 --> 00:04:09,760
difference so we were observing the same

117
00:04:13,270 --> 00:04:12,239
hemisphere pluto the new horizons was

118
00:04:15,910 --> 00:04:13,280
um

119
00:04:18,229 --> 00:04:15,920
so that that's something i'm

120
00:04:21,030 --> 00:04:18,239
very proud of that i was able to do

121
00:04:23,270 --> 00:04:21,040
because i wasn't on the mission

122
00:04:25,510 --> 00:04:23,280
so the data that i got uh are spectral

123
00:04:27,590 --> 00:04:25,520
data cubes so i like to think of them as

124
00:04:29,909 --> 00:04:27,600
a loaf of bread

125
00:04:30,790 --> 00:04:29,919
so if you take a slice out of a loaf of

126
00:04:32,790 --> 00:04:30,800
bread

127
00:04:34,469 --> 00:04:32,800
you have you know 2d slice

128
00:04:36,310 --> 00:04:34,479
and that slice corresponds to a

129
00:04:39,749 --> 00:04:36,320
particular wavelength so if you look at

130
00:04:41,670 --> 00:04:39,759
the bread loaf long ways you're looking

131
00:04:44,950 --> 00:04:41,680
you get an image but if you look at it

132
00:04:47,830 --> 00:04:44,960
sideways you get a spectrum

133
00:04:49,270 --> 00:04:47,840
so we had six nights uh between the 14th

134
00:04:51,670 --> 00:04:49,280
of july and 30th

135
00:04:53,510 --> 00:04:51,680
30th of august all at different center

136
00:04:54,710 --> 00:04:53,520
on different sub-observer longitudes so

137
00:04:56,469 --> 00:04:54,720
you're looking at different parts of

138
00:04:57,749 --> 00:04:56,479

sharon's surface

139
00:04:59,430 --> 00:04:57,759
during each

140
00:05:00,950 --> 00:04:59,440
night

141
00:05:02,070 --> 00:05:00,960
and we did we obtained these in the near

142
00:05:04,870 --> 00:05:02,080
infrared

143
00:05:06,230 --> 00:05:04,880
using adaptive adaptive optics and as

144
00:05:07,990 --> 00:05:06,240
you can see here pluto and charon are

145
00:05:09,029 --> 00:05:08,000
fully separated pluto is the bright one

146
00:05:11,749 --> 00:05:09,039
on the bottom

147
00:05:13,189 --> 00:05:11,759
sharon is the denver one on the top

148
00:05:15,350 --> 00:05:13,199
this is hard to do because they're

149
00:05:18,870 --> 00:05:15,360
separated by less than an arc second

150
00:05:23,430 --> 00:05:22,150
so hasn't been done too much before

151
00:05:25,990 --> 00:05:23,440
and here is what you've all been waiting

152
00:05:28,469 --> 00:05:26,000
for squiggly lines

153
00:05:33,350 --> 00:05:31,430
so this shows the this is the average

154
00:05:35,590 --> 00:05:33,360
spectrum of cheron it's still a little

155
00:05:37,590 --> 00:05:35,600
ratty because sharon is so

156
00:05:40,310 --> 00:05:37,600
faint

157
00:05:41,749 --> 00:05:40,320
we see signatures of

158
00:05:44,710 --> 00:05:41,759
amorphous

159
00:05:46,870 --> 00:05:44,720
water ice crystalline water ice

160
00:05:50,230 --> 00:05:46,880
and ammonia hydrate

161
00:05:54,150 --> 00:05:52,469
darkening agent that nobody's been able

162
00:05:55,830 --> 00:05:54,160
to effectively model

163
00:05:57,909 --> 00:05:55,840

at any point in time

164
00:06:00,350 --> 00:05:57,919
we have no idea what that is

165
00:06:04,309 --> 00:06:00,360
um this feature here

166
00:06:06,710 --> 00:06:04,319
1.65 micron band of is unique to

167
00:06:13,029 --> 00:06:06,720
crystalline water ice it does not show

168
00:06:18,870 --> 00:06:16,870
so what i did was i i fit

169
00:06:22,230 --> 00:06:18,880
i fit gaussians to

170
00:06:24,230 --> 00:06:22,240
this band and to this band to determine

171
00:06:25,430 --> 00:06:24,240
properties of of the species on the

172
00:06:28,230 --> 00:06:25,440
surface

173
00:06:29,909 --> 00:06:28,240
in particular the 1.65 micron band is

174
00:06:31,749 --> 00:06:29,919
temperature dependent

175
00:06:34,070 --> 00:06:31,759
so it depends on

176
00:06:36,150 --> 00:06:34,080
so the the central wavelength of the

177
00:06:37,749 --> 00:06:36,160
band depends on temperature

178
00:06:40,150 --> 00:06:37,759
so you can use that as a gauge of what

179
00:06:42,390 --> 00:06:40,160
the surface temperature is

180
00:06:43,510 --> 00:06:42,400
and for the ammonia hydrate wanted to

181
00:06:45,830 --> 00:06:43,520
figure out

182
00:06:47,510 --> 00:06:45,840
particularly the integrated band area

183
00:06:49,590 --> 00:06:47,520
which is a sort of like an equivalent

184
00:06:51,590 --> 00:06:49,600
width and gives you the amount of the

185
00:06:52,790 --> 00:06:51,600
stuff on the surface that's what it's

186
00:06:54,870 --> 00:06:52,800
related to

187
00:06:57,189 --> 00:06:54,880
so

188
00:06:58,469 --> 00:06:57,199

um and then use the six nights that we

189
00:07:00,070 --> 00:06:58,479
have to determine longitudinal

190
00:07:02,870 --> 00:07:00,080
variability yeah how does this stuff

191
00:07:04,870 --> 00:07:02,880
vary across the surface

192
00:07:06,390 --> 00:07:04,880
there's some limitations to this

193
00:07:08,150 --> 00:07:06,400
uh

194
00:07:09,990 --> 00:07:08,160
in particular you're adding a lot of

195
00:07:11,990 --> 00:07:10,000
noise when you're doing

196
00:07:13,990 --> 00:07:12,000
when you're trying to you know get the

197
00:07:16,070 --> 00:07:14,000
spectrum from the data cube

198
00:07:17,830 --> 00:07:16,080
you're adding way more pixels in each

199
00:07:20,870 --> 00:07:17,840
image than you would if you're doing

200
00:07:22,950 --> 00:07:20,880
long slit so you're making it noisier

201
00:07:24,230 --> 00:07:22,960
however because of the small separations

202
00:07:25,990 --> 00:07:24,240
this is one of the only ways to do this

203
00:07:28,629 --> 00:07:26,000
from the ground to get a separate share

204
00:07:34,550 --> 00:07:30,790
and the the temperature calculation is

205
00:07:38,309 --> 00:07:34,560
not very precise uh however we do end up

206
00:07:43,189 --> 00:07:40,790
other values determined previously

207
00:07:45,110 --> 00:07:43,199
so here's some results

208
00:07:47,430 --> 00:07:45,120
they're not terribly exciting because of

209
00:07:49,270 --> 00:07:47,440
this this noise the lower signal to

210
00:07:50,550 --> 00:07:49,280
noise

211
00:07:52,710 --> 00:07:50,560
we're looking at temperature as a

212
00:07:55,110 --> 00:07:52,720
function of longitude

213
00:07:56,869 --> 00:07:55,120

the red solid line is the average

214
00:07:58,790 --> 00:07:56,879
surface temperature

215
00:08:01,430 --> 00:07:58,800
so that's 41 kelvin

216
00:08:03,110 --> 00:08:01,440
and we the dashed lines show the

217
00:08:04,950 --> 00:08:03,120
uncertainty

218
00:08:07,189 --> 00:08:04,960
all of the values

219
00:08:08,550 --> 00:08:07,199
are consistent with the average value

220
00:08:09,670 --> 00:08:08,560
and with each other

221
00:08:11,589 --> 00:08:09,680
so

222
00:08:14,550 --> 00:08:11,599
no difference in surface temperature

223
00:08:17,189 --> 00:08:15,670
this is important for you know

224
00:08:19,110 --> 00:08:17,199
determining an active cipher

225
00:08:20,869 --> 00:08:19,120
cryovolcanism possibly you expect a

226
00:08:22,869 --> 00:08:20,879
warmer part of the surface for where

227
00:08:24,830 --> 00:08:22,879
cryovolcanism is currently

228
00:08:28,309 --> 00:08:24,840
currently going

229
00:08:29,749 --> 00:08:28,319
on and here's some plots for the ammonia

230
00:08:31,909 --> 00:08:29,759
hydrate band

231
00:08:33,029 --> 00:08:31,919
we see a similar thing there's no

232
00:08:35,110 --> 00:08:33,039
difference in the amount of ammonia

233
00:08:36,949 --> 00:08:35,120
hydrate across the surface of cheron

234
00:08:38,630 --> 00:08:36,959
within our ear bars

235
00:08:40,630 --> 00:08:38,640
and i point to

236
00:08:42,230 --> 00:08:40,640
with this big arrow to the one down here

237
00:08:44,149 --> 00:08:42,240
which is the band area which gives you

238
00:08:45,590 --> 00:08:44,159

the amount of ammonia hydrate on the

239
00:08:47,430 --> 00:08:45,600
surface

240
00:08:49,269 --> 00:08:47,440
appears to be constant

241
00:08:51,829 --> 00:08:49,279
and i'll point out something although it

242
00:08:55,670 --> 00:08:51,839
may not be statistically significant

243
00:09:00,949 --> 00:08:57,829
and this shape

244
00:09:05,110 --> 00:09:02,790
so if that ended up being real that

245
00:09:06,389 --> 00:09:05,120
would be pretty interesting um

246
00:09:09,590 --> 00:09:06,399
we need to

247
00:09:10,870 --> 00:09:09,600
find a way to beat down the noise

248
00:09:13,269 --> 00:09:10,880
so

249
00:09:15,269 --> 00:09:13,279
from new horizons the youngest surface

250
00:09:17,590 --> 00:09:15,279
feat the youngest surface age

251
00:09:20,070 --> 00:09:17,600
is four billion years

252
00:09:21,509 --> 00:09:20,080
so the la the the i mean anything

253
00:09:25,110 --> 00:09:21,519
everything is older than 4 billion years

254
00:09:29,750 --> 00:09:27,190
based on laboratory data you can get

255
00:09:32,070 --> 00:09:29,760
crystalline and amorphous water ice

256
00:09:34,389 --> 00:09:32,080
reaching an equilibrium over time this

257
00:09:36,389 --> 00:09:34,399
happens on the order of you know even

258
00:09:37,990 --> 00:09:36,399
half a billion years

259
00:09:40,070 --> 00:09:38,000
after the ice has been placed on the

260
00:09:42,389 --> 00:09:40,080
surface

261
00:09:43,670 --> 00:09:42,399
so even though your the radiation is

262
00:09:46,870 --> 00:09:43,680
coming in destroying the crystalline

263
00:09:48,230 --> 00:09:46,880

water ice it's thermally recrystallizing

264
00:09:50,630 --> 00:09:48,240
based on temperature so even for

265
00:09:52,070 --> 00:09:50,640
temperatures of 30 kelvin

266
00:09:53,030 --> 00:09:52,080
you get this in less than a billion

267
00:09:55,110 --> 00:09:53,040
years

268
00:09:56,790 --> 00:09:55,120
and the temperature

269
00:09:59,509 --> 00:09:56,800
determines how much crystalline water

270
00:10:04,790 --> 00:10:01,990
it's possible that ammonia is diffusing

271
00:10:06,550 --> 00:10:04,800
through the surface ice to remain on the

272
00:10:11,190 --> 00:10:06,560
surface because it should be destroyed

273
00:10:16,710 --> 00:10:13,110
so there is a replenishment process for

274
00:10:17,670 --> 00:10:16,720
that but it's likely diffusion and if

275
00:10:18,790 --> 00:10:17,680
you know

276
00:10:21,350 --> 00:10:18,800
if this

277
00:10:22,870 --> 00:10:21,360
similar shape for these

278
00:10:24,150 --> 00:10:22,880
is real

279
00:10:25,750 --> 00:10:24,160
uh

280
00:10:27,910 --> 00:10:25,760
that would mean that you know areas

281
00:10:30,230 --> 00:10:27,920
where it's warmer

282
00:10:31,829 --> 00:10:30,240
you're getting more ammonia which means

283
00:10:36,069 --> 00:10:31,839
you know you have faster diffusion rates

284
00:10:38,389 --> 00:10:36,870
so

285
00:10:39,829 --> 00:10:38,399
applying this the rest of the kuiper

286
00:10:41,590 --> 00:10:39,839
belt

287
00:10:43,990 --> 00:10:41,600
crystalline water ice has been detected

288
00:10:45,509 --> 00:10:44,000

on a bunch of other bodies

289
00:10:49,030 --> 00:10:45,519
including haumea

290
00:10:52,310 --> 00:10:49,040
kwawar and orcas as well as haumea's

291
00:10:55,269 --> 00:10:52,320
moons the maka and hayaka

292
00:10:58,150 --> 00:10:55,279
and the haumea collisional family

293
00:11:01,110 --> 00:10:58,160
some of these objects are extremely tiny

294
00:11:02,630 --> 00:11:01,120
maybe 170 kilometers across

295
00:11:04,630 --> 00:11:02,640
you would not expect to research you

296
00:11:06,630 --> 00:11:04,640
know cryovolcanism resurfacing to go on

297
00:11:08,069 --> 00:11:06,640
on a tiny object like that

298
00:11:09,829 --> 00:11:08,079
um

299
00:11:12,389 --> 00:11:09,839
and orcis is the only other object where

300
00:11:14,069 --> 00:11:12,399
ammonia has been detected

301
00:11:14,949 --> 00:11:14,079
you know so we can apply what we've

302
00:11:17,750 --> 00:11:14,959
learned

303
00:11:19,190 --> 00:11:17,760
from about cheron with new horizons

304
00:11:20,550 --> 00:11:19,200
these other objects that we probably

305
00:11:23,269 --> 00:11:20,560
will never go to

306
00:11:25,430 --> 00:11:23,279
and say that you know cryovolcanism

307
00:11:27,430 --> 00:11:25,440
or other replenishment processes are not

308
00:11:32,069 --> 00:11:27,440
required to explain the surface

309
00:11:38,389 --> 00:11:33,590
so

310
00:11:39,829 --> 00:11:38,399
radiogenic heating should be pretty low

311
00:11:42,310 --> 00:11:39,839
for cheron

312
00:11:44,150 --> 00:11:42,320
and tidal heating should be negligible

313
00:11:45,350 --> 00:11:44,160

because it has a nearly circular orbit

314
00:11:48,470 --> 00:11:45,360
around pluto

315
00:11:51,670 --> 00:11:48,480
so you have no possibility of an energy

316
00:11:54,150 --> 00:11:51,680
source likely no ocean

317
00:11:56,949 --> 00:11:54,160
or liquid water under the surface so no

318
00:11:59,110 --> 00:11:56,959
life as we know it um pluto however

319
00:12:01,110 --> 00:11:59,120
could be a different story and i provide

320
00:12:04,470 --> 00:12:01,120
a segway

321
00:12:07,829 --> 00:12:06,069
if you don't like the pun

322
00:12:11,030 --> 00:12:07,839
if you don't like it i can meet you

323
00:12:12,949 --> 00:12:11,040
outside later

324
00:12:15,170 --> 00:12:12,959
so i'll leave you with a haiku

325
00:12:23,690 --> 00:12:15,180
and take any questions

326
00:12:27,509 --> 00:12:23,700
[Applause]

327
00:12:30,069 --> 00:12:27,519
[Laughter]

328
00:12:31,430 --> 00:12:30,079
so i i actually agree with you um i

329
00:12:33,110 --> 00:12:31,440
think it's unlikely that sharon has a

330
00:12:34,470 --> 00:12:33,120
notion today and that he has quiet

331
00:12:35,750 --> 00:12:34,480
volcanism today and

332
00:12:36,790 --> 00:12:35,760
you guys will see

333
00:12:38,550 --> 00:12:36,800
um

334
00:12:40,150 --> 00:12:38,560
just a comment about the difference

335
00:12:42,550 --> 00:12:40,160
between pluto and sharon and i guess

336
00:12:43,350 --> 00:12:42,560
it's slow for the next speaker as well

337
00:12:45,910 --> 00:12:43,360
um

338
00:12:47,750 --> 00:12:45,920

isn't the the reason why their surface

339
00:12:49,590 --> 00:12:47,760
and uh the the fact that pluto has an

340
00:12:51,509 --> 00:12:49,600
atmosphere um

341
00:12:53,910 --> 00:12:51,519
isn't the reason for the dichotomy

342
00:12:55,509 --> 00:12:53,920
uh simply that sharon has a lower

343
00:12:57,350 --> 00:12:55,519
gravity and so it doesn't hold on to any

344
00:12:59,590 --> 00:12:57,360
guesses that would come out of it yep

345
00:13:02,150 --> 00:12:59,600
that's the that's the explanation

346
00:13:04,150 --> 00:13:02,160
it's pretty simple

347
00:13:06,389 --> 00:13:04,160
but you know they start in the same spot

348
00:13:08,230 --> 00:13:06,399
and this is important for you know

349
00:13:10,710 --> 00:13:08,240
detecting things such as non-methane

350
00:13:12,069 --> 00:13:10,720
hydrocarbons potentially on charon at

351
00:13:14,389 --> 00:13:12,079
some point in the past it might have had

352
00:13:15,990 --> 00:13:14,399
these volatile ices but they were lost

353
00:13:17,190 --> 00:13:16,000
and during that time you can get you

354
00:13:19,509 --> 00:13:17,200
know ethane

355
00:13:23,910 --> 00:13:19,519
ethylene acetylene on the surface

356
00:13:23,920 --> 00:13:27,269
other questions