AbSciCon 2019

1
00:00:00,790 --> 00:00:07,320
[Music]

2
00:00:12,269 --> 00:00:09,150
[Applause]

3
00:00:15,820 --> 00:00:12,279
thank you I'd like to acknowledge my

4
00:00:17,589 --> 00:00:15,830
colleagues that are contributors to the

5
00:00:22,569 --> 00:00:17,599
work that I will present and I've listed

6
00:00:24,279 --> 00:00:22,579
in here so if we want to understand what

7
00:00:27,249 --> 00:00:24,289
sort of atmospheres to expect around

8
00:00:29,619 --> 00:00:27,259
ocean exoplanets oceans

9
00:00:33,310 --> 00:00:29,629
what sort of biochemistry in their in

10
00:00:34,720 --> 00:00:33,320
their ocean for oceans that have enough

11
00:00:36,400 --> 00:00:34,730
water to have a high-pressure eyes

12
00:00:38,680 --> 00:00:36,410
they're separating the ocean from the

13
00:00:41,560 --> 00:00:38,690

rocky interior we need to introduce a

14
00:00:44,529 --> 00:00:41,570
lot of hydrophobic chemical species

15
00:00:47,380 --> 00:00:44,539
salts which would actually introduce a

16
00:00:50,439 --> 00:00:47,390
lot of crystal structures like clathrate

17
00:00:52,059 --> 00:00:50,449
hydrates filled eyes salty eyes that may

18
00:00:54,819 --> 00:00:52,069
actually fundamentally change our

19
00:00:58,599 --> 00:00:54,829
understanding of how material is being

20
00:01:01,930 --> 00:00:58,609
transported along high pressure high

21
00:01:04,719 --> 00:01:01,940
spangles so I wanted to make a point

22
00:01:06,940 --> 00:01:04,729
here that clathrate hydrates have very

23
00:01:08,890 --> 00:01:06,950
different characteristics than pure

24
00:01:10,840 --> 00:01:08,900
water and we've known this for quite a

25
00:01:14,080 --> 00:01:10,850
while what happens at even higher

26
00:01:17,130 --> 00:01:14,090
pressures beyond 1 GPA well some field

27
00:01:19,120 --> 00:01:17,140
Isis for example that form after

28
00:01:20,830 --> 00:01:19,130
clathrates will basically be doing

29
00:01:22,720 --> 00:01:20,840
dissociate but they dissociate and

30
00:01:25,240 --> 00:01:22,730
restructuring the field ice they could

31
00:01:27,600 --> 00:01:25,250
withstand pressures up to 100 GPA

32
00:01:30,910 --> 00:01:27,610
spanning the entire high-pressure Iseman

33
00:01:32,950 --> 00:01:30,920
so what are the sort of characteristics

34
00:01:34,810 --> 00:01:32,960
do they have so we looked at MD

35
00:01:37,930 --> 00:01:34,820
simulation we did an empty simulation

36
00:01:41,020 --> 00:01:37,940
for a filled ice of methane using the

37
00:01:43,780 --> 00:01:41,030
software CP 2k and we use that empty

38
00:01:45,280 --> 00:01:43,790

simulation to get the vibrational

39
00:01:46,900 --> 00:01:45,290
spectrum of the crystal structure of

40
00:01:50,050 --> 00:01:46,910
filled ice and I just wanted to make a

41
00:01:53,230 --> 00:01:50,060
point these are the results we got for

42
00:01:56,800 --> 00:01:53,240
the heat capacity so this would be the

43
00:01:58,900 --> 00:01:56,810
heat capacity for methane filled ice

44
00:02:01,390 --> 00:01:58,910
compared with heat capacities for pure

45
00:02:03,970 --> 00:02:01,400
water we see that it almost sits on the

46
00:02:06,280 --> 00:02:03,980
Dulong petit value which would suggest

47
00:02:08,800 --> 00:02:06,290
that filled ices have a very low Debye

48
00:02:11,740 --> 00:02:08,810
temperature and a sort of this weird

49
00:02:14,100 --> 00:02:11,750
behavior of clathrate seems to propagate

50
00:02:16,170 --> 00:02:14,110
also into the field ices in

51
00:02:18,660 --> 00:02:16,180
need a lot more work done in order to

52
00:02:21,180 --> 00:02:18,670
understand how they influenced the

53
00:02:23,460 --> 00:02:21,190
interior dynamics and and mass transport

54
00:02:27,360 --> 00:02:23,470
of ocean exoplanets when you have a

55
00:02:29,220 --> 00:02:27,370
high-pressure ice mantle so if these

56
00:02:31,950 --> 00:02:29,230
crystal structures that I mentioned

57
00:02:34,860 --> 00:02:31,960
actually exist in the interior a key

58
00:02:38,730 --> 00:02:34,870
question is what sort of solubility do

59
00:02:40,380 --> 00:02:38,740
they impose on the overlying ocean it's

60
00:02:42,720 --> 00:02:40,390
very important because it will tell us

61
00:02:45,210 --> 00:02:42,730
what sort of chemistry to expect in the

62
00:02:49,710 --> 00:02:45,220
ocean what sort of atmosphere would form

63
00:02:53,940 --> 00:02:49,720

around such planets and actually these

64
00:02:57,660 --> 00:02:53,950
solubilities are not very well known so

65
00:02:59,190 --> 00:02:57,670
we took advantage of data that is known

66
00:03:03,180 --> 00:02:59,200
from the chemical literature on

67
00:03:06,270 --> 00:03:03,190
hydration shell energies and we use the

68
00:03:08,850 --> 00:03:06,280
Kramer's theory for Brownian particles

69
00:03:12,210 --> 00:03:08,860
to relate the solubility of co2 in

70
00:03:14,729 --> 00:03:12,220
liquid to the solubility of co2 in class

71
00:03:17,070 --> 00:03:14,739
rates and yeah I forgot to mention that

72
00:03:20,370 --> 00:03:17,080
what I want to concentrate on a very

73
00:03:22,979 --> 00:03:20,380
specific problem sorry where you have an

74
00:03:28,340 --> 00:03:22,989
ocean where basically the seafloor of

75
00:03:31,710 --> 00:03:28,350
that ocean is clathrates rich in co2 so

76
00:03:34,140 --> 00:03:31,720
we built a theory that could actually

77
00:03:35,940 --> 00:03:34,150
tell us what the song ability of co2 in

78
00:03:36,840 --> 00:03:35,950
the liquid would be when in equilibrium

79
00:03:39,650 --> 00:03:36,850
with clathrates

80
00:03:42,060 --> 00:03:39,660
and when we compare this theory with

81
00:03:45,120 --> 00:03:42,070
experiments at low pressure up to a few

82
00:03:47,759 --> 00:03:45,130
hundred bars or model is the blue curve

83
00:03:50,340 --> 00:03:47,769
it goes through experimental data pretty

84
00:03:52,650 --> 00:03:50,350
well and we see a very distinct behavior

85
00:03:54,690 --> 00:03:52,660
where the solubility actually increases

86
00:03:56,660 --> 00:03:54,700
with temperature very different when

87
00:03:59,310 --> 00:03:56,670
class rates are not part of the problem

88
00:04:02,130 --> 00:03:59,320

what happens at higher pressure what

89
00:04:04,020 --> 00:04:02,140
happens is the actual seafloor that's

90
00:04:06,270 --> 00:04:04,030
that's a really big problem because we

91
00:04:11,310 --> 00:04:06,280
don't have direct information for the

92
00:04:14,280 --> 00:04:11,320
search for the solubility on the on the

93
00:04:17,780 --> 00:04:14,290
seafloor at a pressure of 1 GPA we can

94
00:04:20,699 --> 00:04:17,790
only infer that data from melting

95
00:04:23,310 --> 00:04:20,709
melting curve depressions so we took

96
00:04:26,820 --> 00:04:23,320
data from Ballinger in tallinn 2013 for

97
00:04:27,960 --> 00:04:26,830
system saturated in co2 and try to infer

98
00:04:30,090 --> 00:04:27,970
what sort of soluble

99
00:04:31,770 --> 00:04:30,100
you would have wedding equilibrium with

100
00:04:34,760 --> 00:04:31,780
clathrates and it's a very delicate

101
00:04:37,740 --> 00:04:34,770
problem if you assume an ideal sort of

102
00:04:40,800 --> 00:04:37,750
solution you get this green shaded area

103
00:04:42,630 --> 00:04:40,810
if you don't assume ID ality and you

104
00:04:44,760 --> 00:04:42,640
consider the fact that it's and you can

105
00:04:47,460 --> 00:04:44,770
correct for activity coefficients you

106
00:04:49,380 --> 00:04:47,470
get this red shaded area and the model I

107
00:04:51,740 --> 00:04:49,390
showed before with Kramer's theory is

108
00:04:54,510 --> 00:04:51,750
this black curve and it sits very nicely

109
00:04:58,620 --> 00:04:54,520
on the continuation of this inferred

110
00:05:00,450 --> 00:04:58,630
data so what we generally know from this

111
00:05:02,370 --> 00:05:00,460
modeling we only use this model to make

112
00:05:04,020 --> 00:05:02,380
interpolations it's very very important

113
00:05:06,000 --> 00:05:04,030

these models are not good to make

114
00:05:08,220 --> 00:05:06,010
extrapolations the experimental data is

115
00:05:10,320 --> 00:05:08,230
very very important but what we

116
00:05:12,510 --> 00:05:10,330
generally know when you are in equity

117
00:05:15,570 --> 00:05:12,520
room with class rates the solubility is

118
00:05:17,580 --> 00:05:15,580
not a strong function of pressure unlike

119
00:05:20,370 --> 00:05:17,590
when you use the Henry's law for example

120
00:05:22,080 --> 00:05:20,380
and it is reversed with temperature

121
00:05:24,030 --> 00:05:22,090
increases when the temperature increases

122
00:05:29,190 --> 00:05:24,040
this is what clathrates do when they're

123
00:05:30,570 --> 00:05:29,200
in the system so that's a very important

124
00:05:33,960 --> 00:05:30,580
thing to know the song the ability

125
00:05:37,710 --> 00:05:33,970
because if you want to consider the pH

126
00:05:41,400 --> 00:05:37,720
of an ocean you you basically want to

127
00:05:43,230 --> 00:05:41,410
solve this set of equations and you have

128
00:05:45,540 --> 00:05:43,240
five equations you need an you need a

129
00:05:47,880 --> 00:05:45,550
variable to constrain the system because

130
00:05:50,850 --> 00:05:47,890
you have six variables and for these

131
00:05:52,740 --> 00:05:50,860
particular planets if you have a sea

132
00:05:55,800 --> 00:05:52,750
floor that's composed of co2 it's an

133
00:05:58,590 --> 00:05:55,810
open system so if it becomes unsaturated

134
00:05:59,969 --> 00:05:58,600
with co2 co2 will enter the ocean

135
00:06:01,969 --> 00:05:59,979
because the clathrates will not be

136
00:06:05,219 --> 00:06:01,979
stable they will keep the ocean

137
00:06:07,350 --> 00:06:05,229
saturated so your solubility is

138
00:06:10,230 --> 00:06:07,360

basically what's governing the pH of the

139
00:06:13,200 --> 00:06:10,240
ocean now here they're charged neutral

140
00:06:15,719 --> 00:06:13,210
any equation that I've written seems

141
00:06:18,240 --> 00:06:15,729
extremely simple it's not true for Earth

142
00:06:20,610 --> 00:06:18,250
where you have a lot of interesting ions

143
00:06:22,320 --> 00:06:20,620
dissolved in the ocean and I want to

144
00:06:25,140 --> 00:06:22,330
touch on

145
00:06:31,380 --> 00:06:25,150
basically explain why we think it may

146
00:06:34,110 --> 00:06:31,390
have this simple form so recently there

147
00:06:38,430 --> 00:06:34,120
has been a lot of studies that have been

148
00:06:40,830 --> 00:06:38,440
published on what happens to Bryan's

149
00:06:43,590 --> 00:06:40,840
solutions at very high pressure

150
00:06:45,930 --> 00:06:43,600
and it seems that if the very

151
00:06:47,670 --> 00:06:45,940
high-pressure the end result is very

152
00:06:49,890 --> 00:06:47,680
different than than from low pressure

153
00:06:53,129 --> 00:06:49,900
where the salt is exalt out of the

154
00:06:58,170 --> 00:06:53,139
structure in very high pressure where I

155
00:06:59,900 --> 00:06:58,180
6 and I 7 are concerned ions dissolved

156
00:07:02,219 --> 00:06:59,910
in the liquid actually become

157
00:07:04,379 --> 00:07:02,229
incorporated as interstitials in the

158
00:07:07,230 --> 00:07:04,389
voids of high pressure isa

159
00:07:10,379 --> 00:07:07,240
juruá Tala studied the system Franco

160
00:07:12,870 --> 00:07:10,389
colander other studies and it's more so

161
00:07:17,310 --> 00:07:12,880
it's more correct for i7 than for I 6

162
00:07:21,320 --> 00:07:17,320
though but an interesting another

163
00:07:24,150 --> 00:07:21,330

interesting experimental result is that

164
00:07:26,879 --> 00:07:24,160
and talk about a paper public by Frank

165
00:07:29,360 --> 00:07:26,889
at al 2008 if you take such a high

166
00:07:32,580 --> 00:07:29,370
pressure I swear it has interstitials

167
00:07:34,890 --> 00:07:32,590
within its voids of ions of salt when

168
00:07:37,620 --> 00:07:34,900
you increase the pressure to 500 K it

169
00:07:40,680 --> 00:07:37,630
seems like that the ions are exalt out

170
00:07:42,990 --> 00:07:40,690
of the ice and form pure grains of dense

171
00:07:45,930 --> 00:07:43,000
salt why is that important and how is

172
00:07:47,850 --> 00:07:45,940
that what does that imply for ocean

173
00:07:51,930 --> 00:07:47,860
exoplanets that have a high pressure ice

174
00:07:53,909 --> 00:07:51,940
mantle so we solved for the thermal

175
00:07:56,659 --> 00:07:53,919
profile let's say this is the bottom

176
00:07:59,640 --> 00:07:56,669
this is the sea floor and then you have

177
00:08:01,680 --> 00:07:59,650
high pressure ice this is the thermal

178
00:08:04,830 --> 00:08:01,690
profile in the high pressure Einstein 6

179
00:08:07,650 --> 00:08:04,840
and I seven and this condition that I've

180
00:08:11,400 --> 00:08:07,660
written here is basically saying that if

181
00:08:13,050 --> 00:08:11,410
this condition is true which for these

182
00:08:16,219 --> 00:08:13,060
planets is true even if you have tiny

183
00:08:18,930 --> 00:08:16,229
fractions of rock in the planet then

184
00:08:21,690 --> 00:08:18,940
basically this is a scaling for the

185
00:08:23,580 --> 00:08:21,700
thermal conductivity and the temperature

186
00:08:25,920 --> 00:08:23,590
gradient of the melting of the melting

187
00:08:27,810 --> 00:08:25,930
curve that the bottom of the ocean the

188
00:08:30,029 --> 00:08:27,820

sea floor is actually constrained to the

189
00:08:33,480 --> 00:08:30,039
melting temperature the the melting

190
00:08:35,699 --> 00:08:33,490
curve of high pressure ice but being

191
00:08:37,740 --> 00:08:35,709
constrained to the melting curve of high

192
00:08:41,730 --> 00:08:37,750
pressure ice places are constrained on

193
00:08:43,769 --> 00:08:41,740
your ability to conductive ly cool and

194
00:08:46,860 --> 00:08:43,779
what this means is that high pressure

195
00:08:49,410 --> 00:08:46,870
ice that is upwelling would at some

196
00:08:52,360 --> 00:08:49,420
point tend to melt and basically

197
00:08:55,150 --> 00:08:52,370
discharge it's hot water into the ocean

198
00:08:57,190 --> 00:08:55,160
but if you're not basically melting your

199
00:08:59,920 --> 00:08:57,200
entire ice mantle and you're in a steady

200
00:09:03,070 --> 00:08:59,930
state then at a lower temperature you

201
00:09:04,570 --> 00:09:03,080
have to rican dents so there so I want

202
00:09:07,030 --> 00:09:04,580
you to have this picture in mind where

203
00:09:09,010 --> 00:09:07,040
you have an ocean that's discharging

204
00:09:10,780 --> 00:09:09,020
that you have high-pressure ice melting

205
00:09:12,730 --> 00:09:10,790
discharging water into the ocean and

206
00:09:18,370 --> 00:09:12,740
then rican dents and creating a new

207
00:09:20,770 --> 00:09:18,380
seafloor also another point that i want

208
00:09:22,470 --> 00:09:20,780
to show that contrary to icy moons

209
00:09:25,480 --> 00:09:22,480
because it's very high pressure

210
00:09:27,100 --> 00:09:25,490
adiabatic temperature profiles differ

211
00:09:28,900 --> 00:09:27,110
from the melting temperatures this is

212
00:09:32,020 --> 00:09:28,910
the melting temperature for I seven

213
00:09:35,320 --> 00:09:32,030

differ they started diverging to

214
00:09:36,910 --> 00:09:35,330
hundreds of hundreds of kelvins so if

215
00:09:39,690 --> 00:09:36,920
you want to create for example a brine

216
00:09:42,040 --> 00:09:39,700
pocket and you want to create localized

217
00:09:45,130 --> 00:09:42,050
mounting you need to overcome a

218
00:09:46,360 --> 00:09:45,140
substantial temperature barrier here so

219
00:09:50,140 --> 00:09:46,370
if you look at is Oh melting

220
00:09:52,690 --> 00:09:50,150
temperatures as a function of pressure

221
00:09:54,430 --> 00:09:52,700
the activity of the solvent which is

222
00:09:56,910 --> 00:09:54,440
water here that you need in order to

223
00:10:00,100 --> 00:09:56,920
create such a huge melting de pressure

224
00:10:01,540 --> 00:10:00,110
melting temperature a depression is you

225
00:10:03,820 --> 00:10:01,550
need the solvent to have an activity of

226
00:10:05,920 --> 00:10:03,830
0.2 we know from experiments that water

227
00:10:08,710 --> 00:10:05,930
does not reach these values somewhere

228
00:10:11,350 --> 00:10:08,720
around 0.7 so you cannot create brunt of

229
00:10:12,670 --> 00:10:11,360
pockets of brine so I I totally for a

230
00:10:15,910 --> 00:10:12,680
lot of things and I want to wrap it up

231
00:10:18,880 --> 00:10:15,920
in a in this sort of cartoon on an

232
00:10:20,920 --> 00:10:18,890
illustration that explains basically

233
00:10:23,050 --> 00:10:20,930
what these experimental data and the

234
00:10:25,030 --> 00:10:23,060
thermal profile basically shows us it

235
00:10:28,420 --> 00:10:25,040
shows us that that if high pressure ice

236
00:10:30,970 --> 00:10:28,430
up welds it melts into the ocean forms a

237
00:10:33,490 --> 00:10:30,980
new ocean floor but the new ocean floor

238
00:10:35,800 --> 00:10:33,500

that forms it actually has a high

239
00:10:38,380 --> 00:10:35,810
fractionation factor of ions dissolved

240
00:10:40,480 --> 00:10:38,390
in the ocean with a new ocean floor more

241
00:10:43,780 --> 00:10:40,490
so far i7 than for I 6 now stroll

242
00:10:46,090 --> 00:10:43,790
results for to in terms of what it means

243
00:10:48,970 --> 00:10:46,100
for the salinity of the ocean but if

244
00:10:51,550 --> 00:10:48,980
this part remixes into the mantle then

245
00:10:53,290 --> 00:10:51,560
when reaching the 500k threshold which

246
00:10:57,360 --> 00:10:53,300
we find that you indeed reach in the

247
00:11:00,550 --> 00:10:57,370
interior these ions that are

248
00:11:02,200 --> 00:11:00,560
interstitials in the ice actually start

249
00:11:04,510 --> 00:11:02,210
to dissolve out of the high pressure

250
00:11:05,480 --> 00:11:04,520
high structure and form grains of salt

251
00:11:08,929 --> 00:11:05,490
that sediment

252
00:11:11,090 --> 00:11:08,939
onto the rocky Court so on the one hand

253
00:11:13,040 --> 00:11:11,100
you have relatively pure water coming

254
00:11:15,499 --> 00:11:13,050
out and you have salt coming in so

255
00:11:18,980 --> 00:11:15,509
there's a pump that may actually start

256
00:11:21,739 --> 00:11:18,990
to desalinate the ocean over time and we

257
00:11:24,109 --> 00:11:21,749
calculated the time scale for this

258
00:11:27,290 --> 00:11:24,119
desalination process it depends on the

259
00:11:29,600 --> 00:11:27,300
fractionation factor of ions between

260
00:11:34,369 --> 00:11:29,610
liquid water and high-pressure ice and

261
00:11:37,730 --> 00:11:34,379
the and the melting rate and if the sea

262
00:11:38,210 --> 00:11:37,740
floor is i7 the timescale is very very

263
00:11:40,850 --> 00:11:38,220

short

264
00:11:43,489 --> 00:11:40,860
it basically desalinate sea ocean very

265
00:11:45,769 --> 00:11:43,499
rapidly if if it's size six which i

266
00:11:48,049 --> 00:11:45,779
think is more reasonable if something

267
00:11:50,150 --> 00:11:48,059
like I six then the time scale becomes

268
00:11:52,309 --> 00:11:50,160
very large but even this large time

269
00:11:53,799 --> 00:11:52,319
scale would suggest that you don't end

270
00:11:56,600 --> 00:11:53,809
up with more than milli molar

271
00:11:58,160 --> 00:11:56,610
concentrations of salt in the ocean so

272
00:12:02,119 --> 00:11:58,170
these oceans could be very rich in

273
00:12:06,460 --> 00:12:02,129
volatiles very poor insults which would

274
00:12:09,410 --> 00:12:06,470
say that the way that we've written our

275
00:12:12,980 --> 00:12:09,420
speciation of the eight of the carbonate

276
00:12:16,220 --> 00:12:12,990
system properly and what this would

277
00:12:19,189 --> 00:12:16,230
suggest is this pH profile in such

278
00:12:21,710 --> 00:12:19,199
oceans so the pH may go from as high as

279
00:12:24,019 --> 00:12:21,720
3.5 at the surface all the way to around

280
00:12:28,730 --> 00:12:24,029
2 at the sea floor so it's a highly

281
00:12:33,319 --> 00:12:28,740
acidic environment and if we plot this

282
00:12:36,340 --> 00:12:33,329
pH temperature die BH temperature that

283
00:12:40,069 --> 00:12:36,350
we have studied on a poly extrema file

284
00:12:42,730 --> 00:12:40,079
plot found that we've taken from kapitza

285
00:12:45,379 --> 00:12:42,740
all we see that it's a pretty barren

286
00:12:47,150 --> 00:12:45,389
region so it could be that it's a rare

287
00:12:48,949 --> 00:12:47,160
environment on earth and that's the

288
00:12:52,129 --> 00:12:48,959

reason why there isn't a lot of life

289
00:12:54,710 --> 00:12:52,139
here it could be substantially a harsh

290
00:12:59,629 --> 00:12:54,720
environment for life but in addition we

291
00:13:02,329 --> 00:12:59,639
have it's a poly it basically is an

292
00:13:04,850 --> 00:13:02,339
environment that is has many stressors

293
00:13:08,090 --> 00:13:04,860
it's not just the agent temperature it

294
00:13:10,670 --> 00:13:08,100
has to combat low salinity as I've just

295
00:13:14,150 --> 00:13:10,680
explained and

296
00:13:17,420 --> 00:13:14,160
way that you may do that is by

297
00:13:20,780 --> 00:13:17,430
introducing an ice camp and a reason

298
00:13:22,880 --> 00:13:20,790
that that may help with some of the

299
00:13:25,970 --> 00:13:22,890
issues of the environment being highly

300
00:13:28,310 --> 00:13:25,980
diluted with salts is with the with is

301
00:13:30,560 --> 00:13:28,320
with the fact that you tactic freezing

302
00:13:33,970 --> 00:13:30,570
within the pores of ice may actually

303
00:13:36,110 --> 00:13:33,980
create niches where you may reach higher

304
00:13:40,880 --> 00:13:36,120
concentrations that may be more

305
00:13:43,850 --> 00:13:40,890
interesting for combating hydrolysis and

306
00:13:56,150 --> 00:13:43,860
creating polymerization and I leave you

307
00:14:04,850 --> 00:13:56,160
with these exclusions a few minutes for

308
00:14:10,079 --> 00:14:08,610
hey as Steve ants again JPL I guess I

309
00:14:12,930 --> 00:14:10,089
didn't understand the mechanism by which

310
00:14:14,400 --> 00:14:12,940
I six exports salt to the bottom it

311
00:14:16,769 --> 00:14:14,410
makes sense to me based on what you said

312
00:14:19,100 --> 00:14:16,779
that I seven would do that the

313
00:14:25,380 --> 00:14:19,110

difference would be inefficiency so

314
00:14:27,360 --> 00:14:25,390
basically the the major point would be

315
00:14:29,280 --> 00:14:27,370
what is the fractionation because this

316
00:14:31,920 --> 00:14:29,290
this actually doesn't depend on I 6 or

317
00:14:33,750 --> 00:14:31,930
i7 right in terms of energy balance

318
00:14:36,360 --> 00:14:33,760
you're gonna have to melt and you're

319
00:14:39,150 --> 00:14:36,370
gonna have to reform a newly a new ice

320
00:14:42,660 --> 00:14:39,160
ocean floor that will mix the point is

321
00:14:44,880 --> 00:14:42,670
how much I salt you actually end up

322
00:14:46,800 --> 00:14:44,890
within this region so the difference is

323
00:14:48,900 --> 00:14:46,810
what is the fractionation factor of

324
00:14:50,850 --> 00:14:48,910
souls between the ocean and the

325
00:14:53,190 --> 00:14:50,860
high-pressure ice that would change

326
00:14:55,139 --> 00:14:53,200
between I six and seven for I seven it

327
00:14:57,360 --> 00:14:55,149
would be very efficient because it has

328
00:14:59,820 --> 00:14:57,370
larger voids for I six it would be

329
00:15:04,139 --> 00:14:59,830
somewhat less it's less efficient but so

330
00:15:07,019 --> 00:15:04,149
that so that's why yeah if I if I apply

331
00:15:09,269 --> 00:15:07,029
to this diagram with uh at Audi it's an

332
00:15:10,350 --> 00:15:09,279
exponential function kind of where i-70

333
00:15:12,090 --> 00:15:10,360
would end up with nothing

334
00:15:14,280 --> 00:15:12,100
okay so I six just has a lower carrying

335
00:15:17,100 --> 00:15:14,290
capacity yeah exact scale exactly and

336
00:15:20,090 --> 00:15:17,110
the key thing about the ocean worlds or

337
00:15:23,940 --> 00:15:20,100
sorry water planet sources ocean moons

338
00:15:25,530 --> 00:15:23,950

is that it pressures and in the water

339
00:15:27,600 --> 00:15:25,540
worlds are high enough that you reach

340
00:15:30,600 --> 00:15:27,610
this dissolution point at the bottom of

341
00:15:34,079 --> 00:15:30,610
the ice yeah I mean there's several I

342
00:15:35,910 --> 00:15:34,089
mean first of all on this arm so the

343
00:15:38,550 --> 00:15:35,920
question so for this pump to work you

344
00:15:42,030 --> 00:15:38,560
have to bring in relatively pure water

345
00:15:45,480 --> 00:15:42,040
and exit and and and you know and and

346
00:15:47,970 --> 00:15:45,490
and and basically sediment the ice right

347
00:15:50,639 --> 00:15:47,980
if you bring the salt back up then you

348
00:15:54,060 --> 00:15:50,649
don't have a pump so for ocean world's

349
00:15:55,870 --> 00:15:54,070
first of all you have a relatively at

350
00:15:58,540 --> 00:15:55,880
you saw the adiabat in the Mel

351
00:16:00,910 --> 00:15:58,550
they really diverge so for icing moons

352
00:16:03,960 --> 00:16:00,920
that temperature is actually because of

353
00:16:06,730 --> 00:16:03,970
the low pressure is not that that

354
00:16:09,100 --> 00:16:06,740
substantial it's a few tens of K you can

355
00:16:11,260 --> 00:16:09,110
easily overcome that and create brined

356
00:16:14,260 --> 00:16:11,270
pockets that can certainly migrate up

357
00:16:17,170 --> 00:16:14,270
certainly if you have like some models

358
00:16:21,370 --> 00:16:17,180
for typing a mixed ice rock layer it

359
00:16:23,550 --> 00:16:21,380
won't be a problem to basically opt well

360
00:16:26,320 --> 00:16:23,560
a brine pocket in this sort of situation

361
00:16:29,890 --> 00:16:26,330
it's very hard to do that you can't

362
00:16:33,310 --> 00:16:29,900
overcome a temperature difference of

363
00:16:38,950 --> 00:16:33,320

hundreds of K due to the high pressure

364
00:16:41,410 --> 00:16:38,960
and and again because beyond 500 K you

365
00:16:44,410 --> 00:16:41,420
don't get the ions as interstitials in

366
00:16:46,510 --> 00:16:44,420
the high pressure ice then you can't get

367
00:16:48,700 --> 00:16:46,520
the ions back as interstitials and you

368
00:16:51,490 --> 00:16:48,710
can't get brine pockets up there as well

369
00:16:53,410 --> 00:16:51,500
so the melting would probably happen

370
00:16:55,120 --> 00:16:53,420
somewhere here where the temperature

371
00:16:57,280 --> 00:16:55,130
difference between the adiabatic and the

372
00:16:59,140 --> 00:16:57,290
melting is not that hot so that's why I

373
00:17:02,740 --> 00:16:59,150
work here but it's not there work for

374
00:17:04,240 --> 00:17:02,750
icy moons is consistent with some recent

375
00:17:07,000 --> 00:17:04,250
literature on the two-phase convection

376
00:17:09,040 --> 00:17:07,010
and icy world and the moon okay it's not

377
00:17:11,110 --> 00:17:09,050
a contradictory okay thanks

378
00:17:14,230 --> 00:17:11,120
I'd like to encourage those with extra

379
00:17:17,170 --> 00:17:14,240
questions to talk to the speaker after

380
00:17:18,589 --> 00:17:17,180
the session so let's thank all the

381
00:17:19,919 --> 00:17:18,599
speakers