305: Geochemistry & Habitability of Alkaline Hydrothermal Vents on Earth & Beyond I

1
00:00:05,349 --> 00:00:02,950
hi everyone um good morning and thank

2
00:00:06,789 --> 00:00:05,359
you for joining us in this hybrid oral

3
00:00:09,190 --> 00:00:06,799
session the geochemistry and

4
00:00:11,190 --> 00:00:09,200
habitability of alkaline hydrothermal

5
00:00:13,350 --> 00:00:11,200
events on earth and beyond

6
00:00:15,509 --> 00:00:13,360
my name is arlene sanchez i'm a graduate

7
00:00:17,269 --> 00:00:15,519
student from stony brook university

8
00:00:19,189 --> 00:00:17,279
and i'll be sharing this session along

9
00:00:21,189 --> 00:00:19,199
with my colleagues here today

10
00:00:23,590 --> 00:00:21,199
we have five great talks to look forward

11
00:00:26,070 --> 00:00:23,600
to today two of which are from our

12
00:00:28,310 --> 00:00:26,080
invited guests dr deb kelly from

13
00:00:30,070 --> 00:00:28,320

university of washington and dr alexis

14
00:00:31,830 --> 00:00:30,080
templeton from the university of

15
00:00:34,389 --> 00:00:31,840
colorado boulder

16
00:00:36,150 --> 00:00:34,399
as a note after each talk we will have a

17
00:00:37,910 --> 00:00:36,160
four-minute q a

18
00:00:38,869 --> 00:00:37,920
where both the in-person and online

19
00:00:40,389 --> 00:00:38,879
audience

20
00:00:43,110 --> 00:00:40,399
will be able to ask their questions so

21
00:00:44,549 --> 00:00:43,120
please feel free to participate i'll go

22
00:00:47,190 --> 00:00:44,559
ahead and let the rest of my colleagues

23
00:00:49,110 --> 00:00:47,200
introduce themselves as well

24
00:00:51,430 --> 00:00:49,120
hi everyone my name is holly rucker i'm

25
00:00:54,229 --> 00:00:51,440
from the university of arizona

26
00:00:55,510 --> 00:00:54,239
and we are hybrid today so

27
00:00:57,670 --> 00:00:55,520
when you come up for your question

28
00:00:59,990 --> 00:00:57,680
please state your name and affiliation

29
00:01:01,830 --> 00:01:00,000
and i'll also ask the same for people on

30
00:01:05,670 --> 00:01:01,840
zoom and we'll try to alternate between

31
00:01:08,230 --> 00:01:05,680
in-person and zoom questions

32
00:01:10,149 --> 00:01:08,240
hi everyone thank you for coming i'm roy

33
00:01:12,390 --> 00:01:10,159
price from stony brook university i can

34
00:01:13,510 --> 00:01:12,400
barely see you with all the lights but

35
00:01:14,950 --> 00:01:13,520
um

36
00:01:16,469 --> 00:01:14,960
yeah i'm i'm a specialist in

37
00:01:19,109 --> 00:01:16,479
hydrothermal vents and in particular

38
00:01:21,749 --> 00:01:19,119

shallow c hydrothermal vents and

39
00:01:23,510 --> 00:01:21,759
some of those are alkaline in nature and

40
00:01:24,950 --> 00:01:23,520
that sort of started the ideas for this

41
00:01:26,469 --> 00:01:24,960
session

42
00:01:28,950 --> 00:01:26,479
um i'll also

43
00:01:30,550 --> 00:01:28,960
introduce uh dr lori barge who's also a

44
00:01:31,830 --> 00:01:30,560
co-convener here

45
00:01:33,590 --> 00:01:31,840
she's not here at the moment she's going

46
00:01:36,310 --> 00:01:33,600
to be in and out she's from jet

47
00:01:37,270 --> 00:01:36,320
propulsion lab in california

48
00:01:39,990 --> 00:01:37,280
um

49
00:01:42,710 --> 00:01:40,000
and i think that's it

50
00:01:44,710 --> 00:01:42,720
great um so we have our first speaker

51
00:02:01,590 --> 00:01:44,720
today as dr dab kelly from the

52
00:02:05,749 --> 00:02:03,830
thank you for the opportunity to present

53
00:02:07,749 --> 00:02:05,759
some summary of the last city work that

54
00:02:09,350 --> 00:02:07,759
our team has been doing and how it can

55
00:02:12,710 --> 00:02:09,360
help inform us about considerations in

56
00:02:14,229 --> 00:02:12,720
the exploration of life elsewhere

57
00:02:17,030 --> 00:02:14,239
last city is one of the most amazing

58
00:02:19,350 --> 00:02:17,040
places on earth it's uh on one million

59
00:02:21,190 --> 00:02:19,360
year old mantle rocks it hosts the

60
00:02:24,150 --> 00:02:21,200
largest hydrothermal vent structures

61
00:02:26,390 --> 00:02:24,160
that are found reach 60 meters in height

62
00:02:29,350 --> 00:02:26,400
they're all carbonate limestone

63
00:02:31,990 --> 00:02:29,360

venting is medium low temperature 40

64
00:02:33,830 --> 00:02:32,000
degrees to about 96 degrees and one of

65
00:02:35,430 --> 00:02:33,840
the spectacular things about this system

66
00:02:37,030 --> 00:02:35,440
is it's

67
00:02:38,869 --> 00:02:37,040
very different than other environments

68
00:02:41,990 --> 00:02:38,879
because it vents

69
00:02:45,110 --> 00:02:42,000
high ph fluids that are very low in

70
00:02:47,509 --> 00:02:45,120
silica and contain no metals the fluids

71
00:02:49,190 --> 00:02:47,519
are also enriched in hydrogen a biogenic

72
00:02:51,509 --> 00:02:49,200
methane and formate another low

73
00:02:53,030 --> 00:02:51,519
molecular hydrocarbons that are a

74
00:02:54,869 --> 00:02:53,040
hallmark of

75
00:02:57,030 --> 00:02:54,879
fluid hydrothermal systems driven by

76
00:02:59,110 --> 00:02:57,040
serpentinization reactions

77
00:02:59,990 --> 00:02:59,120
the fluid chemistry is strongly linked

78
00:03:01,830 --> 00:03:00,000
to

79
00:03:04,710 --> 00:03:01,840
the microbial communities that thrive

80
00:03:06,229 --> 00:03:04,720
within the interior walls of the

81
00:03:07,270 --> 00:03:06,239
carbonate towers as well as on the

82
00:03:08,550 --> 00:03:07,280
outside

83
00:03:10,710 --> 00:03:08,560
and the system is fueled by

84
00:03:13,910 --> 00:03:10,720
serpentinization reactions and

85
00:03:17,270 --> 00:03:13,920
predominantly by cooling of the crustal

86
00:03:19,589 --> 00:03:17,280
rocks in the form of atlantis massif

87
00:03:21,270 --> 00:03:19,599
dating of the limestone chimneys

88
00:03:23,430 --> 00:03:21,280

indicate that this is a very long-lived

89
00:03:28,229 --> 00:03:23,440
target thermal system with that's been

90
00:03:30,070 --> 00:03:28,239
active for at least 150 000 years

91
00:03:31,589 --> 00:03:30,080
as i mentioned the

92
00:03:33,750 --> 00:03:31,599
reason that last city is there is

93
00:03:36,550 --> 00:03:33,760
because of a long-lived attachment fault

94
00:03:38,149 --> 00:03:36,560
that has exposed ultramafic rocks uh

95
00:03:41,030 --> 00:03:38,159
bounded to the south by the atlanta's

96
00:03:42,949 --> 00:03:41,040
transform fault and by the east by the

97
00:03:44,309 --> 00:03:42,959
mid-atlantic bridge the lost city field

98
00:03:46,470 --> 00:03:44,319
itself is

99
00:03:48,949 --> 00:03:46,480
near the top of the atlantis massive

100
00:03:50,630 --> 00:03:48,959
which is a very flat topped mountain

101
00:03:53,589 --> 00:03:50,640
uh it has no volcanic rocks all the

102
00:03:57,190 --> 00:03:53,599
volcanic rocks are to the east uh that

103
00:03:59,350 --> 00:03:57,200
are on the rider blocks uh on the on to

104
00:04:02,869 --> 00:03:59,360
the east on an attachment fault

105
00:04:03,830 --> 00:04:02,879
um so the core of the atlantis massif is

106
00:04:06,470 --> 00:04:03,840
uh

107
00:04:07,910 --> 00:04:06,480
highly altered prototypes and gabbros

108
00:04:09,270 --> 00:04:07,920
and again one of the important things

109
00:04:11,110 --> 00:04:09,280
about when we think about where to look

110
00:04:12,789 --> 00:04:11,120
for other lost cities is it's bounded by

111
00:04:15,830 --> 00:04:12,799
the seismically active transform fault

112
00:04:17,909 --> 00:04:15,840
which keeps the fluid circulation going

113
00:04:20,150 --> 00:04:17,919

and also the second point is that the

114
00:04:24,390 --> 00:04:20,160
heat is largely derived from residual

115
00:04:26,150 --> 00:04:24,400
heat within the missive rocks itself

116
00:04:28,629 --> 00:04:26,160
as it's one of the most beautiful places

117
00:04:31,110 --> 00:04:28,639
i think on the planet uh this is video

118
00:04:33,510 --> 00:04:31,120
taken during a program that we did with

119
00:04:34,790 --> 00:04:33,520
noah and bob ballard's group uh and this

120
00:04:36,790 --> 00:04:34,800
shows the

121
00:04:39,110 --> 00:04:36,800
a parasitic chimney called the imax

122
00:04:42,629 --> 00:04:39,120
flange or imax tower that rises three

123
00:04:44,790 --> 00:04:42,639
stories uh outside of the main growing

124
00:04:46,230 --> 00:04:44,800
from the outside of the main poseidon

125
00:04:48,550 --> 00:04:46,240
structure

126
00:04:51,510 --> 00:04:48,560
my student chris ludwig did dating

127
00:04:52,950 --> 00:04:51,520
uranium thorium dating of the

128
00:04:55,030 --> 00:04:52,960
multiple

129
00:04:57,350 --> 00:04:55,040
samples recovered from lost city and she

130
00:04:59,510 --> 00:04:57,360
documents that the system is very long

131
00:05:00,390 --> 00:04:59,520
lived with active vending over 150 000

132
00:05:02,310 --> 00:05:00,400
years

133
00:05:04,150 --> 00:05:02,320
this is a underwater upside down

134
00:05:05,510 --> 00:05:04,160
waterfall one of the flanges and it's

135
00:05:07,830 --> 00:05:05,520
quite spectacular it's one of the

136
00:05:09,909 --> 00:05:07,840
samples the areas we sampled for

137
00:05:11,990 --> 00:05:09,919
microbial communities but you can see

138
00:05:14,629 --> 00:05:12,000

that these are diffuse flow fluids they

139
00:05:16,230 --> 00:05:14,639
have no particulates no metals and when

140
00:05:18,150 --> 00:05:16,240
we consider where to look for other lost

141
00:05:21,990 --> 00:05:18,160
cities this is going to be important

142
00:05:24,390 --> 00:05:22,790
i won't go over this with

143
00:05:26,230 --> 00:05:24,400
pentatonization reactions but only to

144
00:05:27,670 --> 00:05:26,240
say that uh it's very clear that

145
00:05:29,029 --> 00:05:27,680
subpoenaization and exothermic

146
00:05:31,510 --> 00:05:29,039
oxycodonization

147
00:05:32,790 --> 00:05:31,520
uh by itself is not enough to drive the

148
00:05:34,310 --> 00:05:32,800
heat there's not enough heat coming from

149
00:05:35,350 --> 00:05:34,320
that to drive the hydrothermal systems

150
00:05:37,430 --> 00:05:35,360
that we see

151
00:05:39,430 --> 00:05:37,440
and the second point is that uh

152
00:05:40,950 --> 00:05:39,440
associated with pentonization is a very

153
00:05:43,189 --> 00:05:40,960
large volume increase up to forty

154
00:05:45,670 --> 00:05:43,199
percent and so this is important when we

155
00:05:48,310 --> 00:05:45,680
think about how we keep lost city type

156
00:05:50,830 --> 00:05:48,320
systems active because this while

157
00:05:53,350 --> 00:05:50,840
increasing volume can both

158
00:05:55,909 --> 00:05:53,360
expand to close fractures but it can

159
00:05:58,469 --> 00:05:55,919
also open fractures work by gretchen for

160
00:06:00,390 --> 00:05:58,479
green shows that the

161
00:06:02,309 --> 00:06:00,400
the basement temperatures in this area

162
00:06:04,150 --> 00:06:02,319
are about a hundred a little over 150

163
00:06:06,469 --> 00:06:04,160

degrees c

164
00:06:08,790 --> 00:06:06,479
the hydrothermal fluids people know now

165
00:06:09,590 --> 00:06:08,800
are marked by they're very unique uh

166
00:06:12,550 --> 00:06:09,600
there's

167
00:06:14,150 --> 00:06:12,560
virtually no co2 in these fluids uh and

168
00:06:16,390 --> 00:06:14,160
the high hydrogen and methane is a

169
00:06:17,430 --> 00:06:16,400
hallmark of serpentinization influenced

170
00:06:18,870 --> 00:06:17,440
fluids

171
00:06:21,909 --> 00:06:18,880
the other two places that i've shown

172
00:06:24,230 --> 00:06:21,919
here for context are logic and rainbow

173
00:06:26,790 --> 00:06:24,240
which is hybrid systems that include

174
00:06:29,270 --> 00:06:26,800
both the broiler influenced reactions as

175
00:06:30,950 --> 00:06:29,280
well high temperature heroic reactions

176
00:06:33,350 --> 00:06:30,960
as well as influences by

177
00:06:35,830 --> 00:06:33,360
serpentinization and these fluids are

178
00:06:37,430 --> 00:06:35,840
360 degrees c they have very enriched

179
00:06:39,029 --> 00:06:37,440
metal concentrations but they also have

180
00:06:40,950 --> 00:06:39,039
the hallmark of synthetization which is

181
00:06:42,870 --> 00:06:40,960
high methane and high hydrogen but they

182
00:06:43,670 --> 00:06:42,880
also have very high co2

183
00:06:46,309 --> 00:06:43,680
the

184
00:06:49,110 --> 00:06:46,319
mineralogy of lost city is very very

185
00:06:50,870 --> 00:06:49,120
simple it's basically aragonite that is

186
00:06:53,029 --> 00:06:50,880
metastable so it converts to calcite

187
00:06:55,110 --> 00:06:53,039
over time and then as seawater mixes

188
00:06:56,629 --> 00:06:55,120

into the pores too many walls uh forms

189
00:06:58,309 --> 00:06:56,639
blue site

190
00:06:59,990 --> 00:06:58,319
um

191
00:07:02,390 --> 00:07:00,000
and this is just to say again that the

192
00:07:04,150 --> 00:07:02,400
the i'll go over the the

193
00:07:06,390 --> 00:07:04,160
hydrocarbons in a few minutes but they

194
00:07:08,070 --> 00:07:06,400
are both abiogenic and look to be

195
00:07:09,589 --> 00:07:08,080
biogenic sourced

196
00:07:11,830 --> 00:07:09,599
this is work by

197
00:07:15,350 --> 00:07:11,840
uh susan lang and this is part of our

198
00:07:18,710 --> 00:07:15,360
phd work and as you can see the formate

199
00:07:21,350 --> 00:07:18,720
values are quite high 36 to 150 58

200
00:07:23,270 --> 00:07:21,360
micromolar and acetate is 1 to 35

201
00:07:25,110 --> 00:07:23,280
micromolar so they are elevated with

202
00:07:27,350 --> 00:07:25,120
respect to other environments

203
00:07:28,950 --> 00:07:27,360
compound-specific carbon-14 analyses

204
00:07:31,430 --> 00:07:28,960
indicate that the format is manually

205
00:07:35,350 --> 00:07:31,440
derived that is it's about abiotic in

206
00:07:37,589 --> 00:07:35,360
some areas and it fuels sulfate reduces

207
00:07:40,070 --> 00:07:37,599
the acetate however may be a microbial

208
00:07:42,390 --> 00:07:40,080
byproduct of form burn for pentanization

209
00:07:45,589 --> 00:07:42,400
ferment fermentation of larger organic

210
00:07:49,990 --> 00:07:48,469
the too many walls are incredibly porous

211
00:07:52,309 --> 00:07:50,000
they're spectacular to see when you cut

212
00:07:54,390 --> 00:07:52,319
them open the outer chimney walls

213
00:07:57,189 --> 00:07:54,400

where there's diffuse venting have very

214
00:07:59,589 --> 00:07:57,199
thick almost kelp like beds so my thick

215
00:08:02,230 --> 00:07:59,599
microbial mats that are waving in the in

216
00:08:04,070 --> 00:08:02,240
the currents but as you go into this

217
00:08:05,909 --> 00:08:04,080
chimney you can see that

218
00:08:07,110 --> 00:08:05,919
that it's incredibly porous this is a

219
00:08:10,070 --> 00:08:07,120
thin section

220
00:08:12,309 --> 00:08:10,080
of uh near the outside of a chimney

221
00:08:14,309 --> 00:08:12,319
and for scale it's about one inch across

222
00:08:16,469 --> 00:08:14,319
but you can see this very anastomosing

223
00:08:19,189 --> 00:08:16,479
complex structure of carbonate my

224
00:08:22,230 --> 00:08:19,199
hypothesis is that in this case it was

225
00:08:23,990 --> 00:08:22,240
um filamentous bacteria when seawater

226
00:08:26,790 --> 00:08:24,000
the high seawater

227
00:08:28,790 --> 00:08:26,800
seawater bicarbonate mixes with the high

228
00:08:31,189 --> 00:08:28,800
ph fluids the bicarbonate drops out in

229
00:08:33,269 --> 00:08:31,199
forms of carbonate so my guess is that

230
00:08:35,350 --> 00:08:33,279
these are basically fossilized

231
00:08:36,870 --> 00:08:35,360
filamentous bacteria that you're seeing

232
00:08:39,350 --> 00:08:36,880
in this one image

233
00:08:40,550 --> 00:08:39,360
the um it's a great environment because

234
00:08:42,389 --> 00:08:40,560
it's a high energy environment with a

235
00:08:45,190 --> 00:08:42,399
lot of hydrogen but also mixing with

236
00:08:46,790 --> 00:08:45,200
with seawater uh sulfate and so

237
00:08:48,150 --> 00:08:46,800
basically they um

238
00:08:50,310 --> 00:08:48,160

supported a

239
00:08:52,070 --> 00:08:50,320
large variety of microbial communities

240
00:08:54,150 --> 00:08:52,080
the porous interior walls however are

241
00:08:57,990 --> 00:08:54,160
dominated by archaea biofilms that are

242
00:09:02,070 --> 00:09:00,389
this is worked by billy brazelton i'm

243
00:09:05,509 --> 00:09:02,080
really proud of this this paper it's a

244
00:09:07,670 --> 00:09:05,519
2010 pnes paper that billy and

245
00:09:10,949 --> 00:09:07,680
chris ludwig did and they combined the

246
00:09:13,910 --> 00:09:10,959
dating that chris did with uh 454

247
00:09:16,470 --> 00:09:13,920
analysis and it shows in this case um

248
00:09:20,550 --> 00:09:16,480
his paper also talks about bacteria but

249
00:09:22,150 --> 00:09:20,560
this is just in results of 454 analysis

250
00:09:23,110 --> 00:09:22,160
on the archaea and it shows that they

251
00:09:27,910 --> 00:09:23,120
adapt

252
00:09:30,310 --> 00:09:27,920
over 100 uh 1 200 years the oldest

253
00:09:32,070 --> 00:09:30,320
chimneys which is extinct

254
00:09:35,350 --> 00:09:32,080
are dominated by low temperature

255
00:09:37,269 --> 00:09:35,360
anaerobic methane oxidizers nme1 while

256
00:09:39,030 --> 00:09:37,279
the youngest chimneys are dominated by

257
00:09:41,190 --> 00:09:39,040
lassity mcdonough sarcomas these are

258
00:09:42,710 --> 00:09:41,200
high temperature anaerobic methane

259
00:09:44,230 --> 00:09:42,720
metabolizers

260
00:09:45,910 --> 00:09:44,240
one of the interesting results of

261
00:09:48,550 --> 00:09:45,920
billy's work is he shows that the rear

262
00:09:50,230 --> 00:09:48,560
sequences referred to as a reviser are

263
00:09:51,910 --> 00:09:50,240

more abundant in the younger samples

264
00:09:54,230 --> 00:09:51,920
corresponding to environmental change

265
00:09:55,670 --> 00:09:54,240
and they can be done become dominant

266
00:09:57,509 --> 00:09:55,680
members of the communities as the

267
00:09:59,430 --> 00:09:57,519
environment changes over time

268
00:10:01,190 --> 00:09:59,440
i would love to go back to last city and

269
00:10:04,870 --> 00:10:01,200
core these uh similar to like when

270
00:10:07,190 --> 00:10:04,880
you're pouring for um to make uh

271
00:10:09,509 --> 00:10:07,200
sugar out of maple trees uh core into

272
00:10:11,590 --> 00:10:09,519
the structures and uh juice do

273
00:10:13,190 --> 00:10:11,600
sequencing from the oldest to the

274
00:10:15,509 --> 00:10:13,200
youngest my guess is life studies

275
00:10:17,590 --> 00:10:15,519
probably i've been active for more than

276
00:10:20,230 --> 00:10:17,600
uh 200 000 years so it'd be a great

277
00:10:22,389 --> 00:10:20,240
study to pursue

278
00:10:25,110 --> 00:10:22,399
so challenges in this exploration for

279
00:10:27,030 --> 00:10:25,120
lost city um as i mentioned the fluids

280
00:10:29,430 --> 00:10:27,040
are conscious of black smokers that have

281
00:10:31,430 --> 00:10:29,440
a lot of particulates metal sulfides

282
00:10:33,590 --> 00:10:31,440
coming out

283
00:10:34,870 --> 00:10:33,600
they look like fire hoses and very thick

284
00:10:37,350 --> 00:10:34,880
dark plumes

285
00:10:39,030 --> 00:10:37,360
the challenge with lost city is that um

286
00:10:41,750 --> 00:10:39,040
the fluids are low temperature they're

287
00:10:43,829 --> 00:10:41,760
dominated by diffuse flow and so the

288
00:10:47,110 --> 00:10:43,839

rise heights of the plumes are not very

289
00:10:49,110 --> 00:10:47,120
large um you know less than 25 50 meters

290
00:10:51,190 --> 00:10:49,120
certainly a lot less than 100 meters and

291
00:10:53,509 --> 00:10:51,200
they're absent in particulate so how do

292
00:10:55,509 --> 00:10:53,519
we go about investigating new lost

293
00:10:57,190 --> 00:10:55,519
cities and this work is um

294
00:10:59,509 --> 00:10:57,200
shown one two different ways that we've

295
00:11:00,870 --> 00:10:59,519
done it one is by vertical class from a

296
00:11:02,550 --> 00:11:00,880
ship using a

297
00:11:04,069 --> 00:11:02,560
instrument package that measures

298
00:11:07,430 --> 00:11:04,079
conductivity temperature and depth but

299
00:11:09,110 --> 00:11:07,440
also allows fluid sampling and discrete

300
00:11:11,990 --> 00:11:09,120
discrete depths

301
00:11:14,069 --> 00:11:12,000
and this just shows the plumes from from

302
00:11:15,590 --> 00:11:14,079
discrete sample bottles of of hydrogen

303
00:11:16,389 --> 00:11:15,600
and you can see that they do not rise

304
00:11:18,710 --> 00:11:16,399
very

305
00:11:21,030 --> 00:11:18,720
far above the top of the machine

306
00:11:22,790 --> 00:11:21,040
in a more recent study that came out of

307
00:11:26,150 --> 00:11:22,800
billy and uh

308
00:11:27,670 --> 00:11:26,160
and um susan's cruise uh the rov jason

309
00:11:29,910 --> 00:11:27,680
was flying about five meters off the

310
00:11:32,069 --> 00:11:29,920
bottom this lower image here

311
00:11:34,310 --> 00:11:32,079
and eh is one of the best ways that you

312
00:11:36,310 --> 00:11:34,320
can detect these hydrothermal plumes um

313
00:11:39,030 --> 00:11:36,320

the oxidation reduction potential and

314
00:11:41,990 --> 00:11:39,040
this shows the temperature in blue the

315
00:11:43,990 --> 00:11:42,000
water depth of the vehicle and then uh

316
00:11:45,990 --> 00:11:44,000
eh has shown her oxidation reduction

317
00:11:48,389 --> 00:11:46,000
potential is shown in red here and what

318
00:11:51,190 --> 00:11:48,399
you can see is um that there's a very

319
00:11:54,710 --> 00:11:51,200
strong anomaly uh uh

320
00:11:56,470 --> 00:11:54,720
right where they also imaged a carbonate

321
00:11:58,790 --> 00:11:56,480
diffuse flow sites so this is a great

322
00:12:00,710 --> 00:11:58,800
way to it's probably the best way the

323
00:12:03,030 --> 00:12:00,720
most easiest way to detect a

324
00:12:05,190 --> 00:12:03,040
hydrothermal system but it means that in

325
00:12:06,710 --> 00:12:05,200
other areas in order to

326
00:12:08,870 --> 00:12:06,720
discover these systems you've got to

327
00:12:10,629 --> 00:12:08,880
take a autonomous underwater vehicle and

328
00:12:12,550 --> 00:12:10,639
fly it very close to the sea floor so

329
00:12:15,509 --> 00:12:12,560
there are different challenges in how we

330
00:12:18,069 --> 00:12:15,519
look for other systems like this

331
00:12:20,069 --> 00:12:18,079
finally um just a summary of some of the

332
00:12:22,470 --> 00:12:20,079
considerations when we look for

333
00:12:23,190 --> 00:12:22,480
new lost city mission considerations one

334
00:12:24,790 --> 00:12:23,200
is

335
00:12:26,389 --> 00:12:24,800
you really need an alternative system

336
00:12:28,550 --> 00:12:26,399
with active faulting it's got to keep

337
00:12:31,190 --> 00:12:28,560
the flow channels open and propagation

338
00:12:33,829 --> 00:12:31,200

of fractures down into the ultramafic

339
00:12:35,590 --> 00:12:33,839
rocks so that you keep reacting with uh

340
00:12:37,509 --> 00:12:35,600
olivine and other other minerals there

341
00:12:38,949 --> 00:12:37,519
to get the fluid chemistry that we see

342
00:12:40,629 --> 00:12:38,959
the high ph's

343
00:12:42,629 --> 00:12:40,639
the heat source exothermic

344
00:12:44,550 --> 00:12:42,639
surpatonization reaction is not enough

345
00:12:47,269 --> 00:12:44,560
to drive the last city hydrothermal

346
00:12:49,590 --> 00:12:47,279
systems but you really need some warm

347
00:12:50,790 --> 00:12:49,600
residual warm crustal rocks

348
00:12:53,030 --> 00:12:50,800
in order to

349
00:12:54,389 --> 00:12:53,040
to make sure that the heat source is

350
00:12:57,269 --> 00:12:54,399
there and it's going to be active for a

351
00:12:58,470 --> 00:12:57,279
long time and finally um you know one of

352
00:13:00,150 --> 00:12:58,480
the biggest challenges that i just

353
00:13:02,150 --> 00:13:00,160
mentioned is that the low rise height of

354
00:13:04,470 --> 00:13:02,160
the plumes and lack of particulates

355
00:13:06,389 --> 00:13:04,480
really requires that you fly very close

356
00:13:08,310 --> 00:13:06,399
to the sea floor and as i mentioned

357
00:13:10,629 --> 00:13:08,320
before the the

358
00:13:12,949 --> 00:13:10,639
whatever the vehicle is that you uh are

359
00:13:14,870 --> 00:13:12,959
going to use that you have a eh sensor

360
00:13:17,670 --> 00:13:14,880
on it because it definitely is

361
00:13:18,710 --> 00:13:17,680
the easiest and um best way to pick out

362
00:13:21,430 --> 00:13:18,720
the

363
00:13:34,550 --> 00:13:21,440

plume anomalies so thank you and i look

364
00:13:37,350 --> 00:13:36,069
okay we can start

365
00:13:49,030 --> 00:13:37,360
the q a

366
00:13:53,189 --> 00:13:51,189
hi deborah sanjay some university of

367
00:13:54,949 --> 00:13:53,199
washington alumnus thank you for your

368
00:13:57,350 --> 00:13:54,959
presentation i've i've been looking to

369
00:13:59,030 --> 00:13:57,360
share the story of discovery of velocity

370
00:14:00,870 --> 00:13:59,040
because as you said it's such an

371
00:14:03,590 --> 00:14:00,880
impressive place but i haven't been able

372
00:14:05,430 --> 00:14:03,600
to find the story of the discovery from

373
00:14:07,590 --> 00:14:05,440
your words from your perspective have

374
00:14:09,990 --> 00:14:07,600
you published that

375
00:14:11,829 --> 00:14:10,000
um no i think there's some there were

376
00:14:14,870 --> 00:14:11,839
some video things that were published it

377
00:14:17,350 --> 00:14:14,880
was it was uh in 2000 the

378
00:14:19,750 --> 00:14:17,360
atlantis massif is was one of the first

379
00:14:22,150 --> 00:14:19,760
mapped uh large attachment systems that

380
00:14:24,790 --> 00:14:22,160
had the characteristics the lineations

381
00:14:26,949 --> 00:14:24,800
um that we seen and we were on an alvin

382
00:14:28,629 --> 00:14:26,959
alvin dive um

383
00:14:29,350 --> 00:14:28,639
uh we used alvin and then at night we

384
00:14:32,310 --> 00:14:29,360
would

385
00:14:34,389 --> 00:14:32,320
do camera toes up and down the vertical

386
00:14:37,110 --> 00:14:34,399
cliffs to try and get a better photo

387
00:14:39,509 --> 00:14:37,120
mosaic come and get a better picture of

388
00:14:41,430 --> 00:14:39,519

the east face of the south face of them

389
00:14:43,430 --> 00:14:41,440
see there and

390
00:14:45,750 --> 00:14:43,440
towards the very end of that cruise um

391
00:14:48,470 --> 00:14:45,760
of course around midnight gretchen fruit

392
00:14:50,629 --> 00:14:48,480
green came flying into my cabin and said

393
00:14:52,230 --> 00:14:50,639
i think we found something

394
00:14:54,550 --> 00:14:52,240
and we um

395
00:14:57,189 --> 00:14:54,560
the camera was a old system just black

396
00:14:58,949 --> 00:14:57,199
and white and towed around with the ship

397
00:15:00,230 --> 00:14:58,959
uh you couldn't really drive it around

398
00:15:01,590 --> 00:15:00,240
and so we

399
00:15:04,310 --> 00:15:01,600
went running into the van because i had

400
00:15:06,150 --> 00:15:04,320
done a lot of hydrothermal work um and

401
00:15:07,750 --> 00:15:06,160
uh it was very clear that

402
00:15:10,150 --> 00:15:07,760
uh we didn't have any map or anything

403
00:15:12,629 --> 00:15:10,160
that time were seen in sonar so we

404
00:15:14,629 --> 00:15:12,639
we mapped uh we spent the like i don't

405
00:15:16,710 --> 00:15:14,639
know several hours until the wee hours

406
00:15:18,949 --> 00:15:16,720
of the morning looking at the

407
00:15:21,030 --> 00:15:18,959
black and white photos and then uh did

408
00:15:24,550 --> 00:15:21,040
the follow on alvin dive and then the

409
00:15:26,710 --> 00:15:24,560
next day um jeff carson and i dove

410
00:15:29,430 --> 00:15:26,720
uh we landed in a uh we didn't have very

411
00:15:31,269 --> 00:15:29,440
good navigation took us quite a while to

412
00:15:32,949 --> 00:15:31,279
uh come into the field

413
00:15:35,269 --> 00:15:32,959

uh and we'd driven around a lot so we

414
00:15:36,949 --> 00:15:35,279
only had a i think four hour bottom time

415
00:15:39,110 --> 00:15:36,959
um and at the end of the dive we were

416
00:15:40,389 --> 00:15:39,120
out of power and i said uh we're up but

417
00:15:41,670 --> 00:15:40,399
we didn't know then we were up at the

418
00:15:43,030 --> 00:15:41,680
top up beside

419
00:15:45,350 --> 00:15:43,040
the tallest structure and i said well

420
00:15:46,710 --> 00:15:45,360
let's just let's just float down and see

421
00:15:49,030 --> 00:15:46,720
you know see how

422
00:15:50,710 --> 00:15:49,040
how um tall this chimney is and we just

423
00:15:52,790 --> 00:15:50,720
kept going and going and going and it

424
00:15:54,550 --> 00:15:52,800
turned out it was 60 meters so um and

425
00:15:56,150 --> 00:15:54,560
then uh you know these chimneys were

426
00:15:57,269 --> 00:15:56,160
white you know bright white we were

427
00:15:59,350 --> 00:15:57,279
sitting there

428
00:16:01,910 --> 00:15:59,360
uh on the ship to atlantis the mother

429
00:16:03,509 --> 00:16:01,920
ship for alvin and then um on the

430
00:16:05,509 --> 00:16:03,519
atlantis fracture zone in the last mess

431
00:16:07,430 --> 00:16:05,519
even so i was thinking that these things

432
00:16:09,670 --> 00:16:07,440
look like roman columns or greek columns

433
00:16:11,749 --> 00:16:09,680
and so that's why we call it last city

434
00:16:13,030 --> 00:16:11,759
so the short version

435
00:16:15,030 --> 00:16:13,040
it was it was phenomenal it was

436
00:16:17,110 --> 00:16:15,040
phenomenal it was really cool it's

437
00:16:19,030 --> 00:16:17,120
amazing i i would love to encourage you

438
00:16:21,509 --> 00:16:19,040

to write that story down on people's

439
00:16:27,509 --> 00:16:21,519
words and share it we'd love to do that

440
00:16:33,269 --> 00:16:31,110
hi morgan cable jpl fantastic talk i had

441
00:16:34,710 --> 00:16:33,279
a question about the particulates that

442
00:16:36,150 --> 00:16:34,720
you mentioned you said that they don't

443
00:16:38,310 --> 00:16:36,160
they don't rise very high i was on the

444
00:16:40,790 --> 00:16:38,320
order of like hundreds of meters

445
00:16:43,749 --> 00:16:40,800
and the reason i'm asking is because at

446
00:16:45,990 --> 00:16:43,759
enceladus in the e-ring around saturn we

447
00:16:48,389 --> 00:16:46,000
see these silica nanograins

448
00:16:49,990 --> 00:16:48,399
that we believe are derived from from

449
00:16:51,990 --> 00:16:50,000
the plume and from the ocean and so i'm

450
00:16:53,670 --> 00:16:52,000
wondering if you can comment on how

451
00:16:55,269 --> 00:16:53,680
particulates or flocculates and things

452
00:16:57,350 --> 00:16:55,279
that might form in these hydrothermal

453
00:16:58,870 --> 00:16:57,360
systems might make it up to the top of

454
00:16:59,990 --> 00:16:58,880
the water column and potentially be

455
00:17:03,030 --> 00:17:00,000
expressed

456
00:17:04,630 --> 00:17:03,040
uh in a plume of an ocean world

457
00:17:05,669 --> 00:17:04,640
yeah that's a good so

458
00:17:07,909 --> 00:17:05,679
um

459
00:17:09,829 --> 00:17:07,919
yeah i don't i don't see the well for

460
00:17:10,630 --> 00:17:09,839
last city there's zero particulates and

461
00:17:13,510 --> 00:17:10,640
so

462
00:17:16,630 --> 00:17:13,520
um the only the only signature we have

463
00:17:18,390 --> 00:17:16,640

is is from the the chemistry right

464
00:17:20,309 --> 00:17:18,400
but in black smoker systems certainly

465
00:17:22,069 --> 00:17:20,319
the rise heights are you know they can

466
00:17:24,390 --> 00:17:22,079
be a few hundred meters off the sea

467
00:17:26,150 --> 00:17:24,400
floor um i would guess we don't really

468
00:17:28,230 --> 00:17:26,160
talk too much about currents right but

469
00:17:29,750 --> 00:17:28,240
depending on the topography and the

470
00:17:31,590 --> 00:17:29,760
currents there's you know there's one

471
00:17:34,070 --> 00:17:31,600
way you can get them up there is is

472
00:17:35,750 --> 00:17:34,080
depend as if you have currents but um it

473
00:17:37,669 --> 00:17:35,760
all depends on the density structure

474
00:17:44,470 --> 00:17:37,679
right of whatever that overlying water

475
00:17:47,909 --> 00:17:46,950
hi deb this is chris german from hui um

476
00:17:49,590 --> 00:17:47,919
hey chris

477
00:17:51,669 --> 00:17:49,600
you made a really important point i

478
00:17:53,029 --> 00:17:51,679
think about the the need to

479
00:17:55,190 --> 00:17:53,039
come up with clever ways to actually

480
00:17:56,310 --> 00:17:55,200
search and find more lost cities but

481
00:17:59,270 --> 00:17:56,320
the thing i was going to point of like

482
00:18:00,789 --> 00:17:59,280
given how much stuff we continue to find

483
00:18:02,630 --> 00:18:00,799
how often do you think the conditions

484
00:18:04,070 --> 00:18:02,640
for velocity might recur on our planet

485
00:18:06,310 --> 00:18:04,080
and how many more lost cities might be

486
00:18:08,070 --> 00:18:06,320
out there you know it's going to be hard

487
00:18:09,590 --> 00:18:08,080
to go find them but you know do you

488
00:18:11,190 --> 00:18:09,600

think there's just one or two or could

489
00:18:13,190 --> 00:18:11,200
they be have three you know

490
00:18:15,590 --> 00:18:13,200
no i actually think they're ubiquitous

491
00:18:17,830 --> 00:18:15,600
right and and the reason i say that is

492
00:18:19,990 --> 00:18:17,840
particularly in slow and as you know in

493
00:18:22,070 --> 00:18:20,000
slow and ultra slow spreading centers

494
00:18:24,390 --> 00:18:22,080
um where we see these transform ridge

495
00:18:25,990 --> 00:18:24,400
intersections these machines are are

496
00:18:28,310 --> 00:18:26,000
very very common right they're they're a

497
00:18:30,230 --> 00:18:28,320
hallmark it's just that people have

498
00:18:32,070 --> 00:18:30,240
always focused um

499
00:18:34,789 --> 00:18:32,080
you know on where the black smokers are

500
00:18:37,270 --> 00:18:34,799
right and so to drive 25 kilometers off

501
00:18:39,270 --> 00:18:37,280
axis um we tried to get jeff carson i

502
00:18:41,110 --> 00:18:39,280
tried to get funded three times to go

503
00:18:42,789 --> 00:18:41,120
there's another receive identical

504
00:18:45,190 --> 00:18:42,799
absolutely identical to

505
00:18:46,950 --> 00:18:45,200
the one that lost cities sitting on um

506
00:18:48,630 --> 00:18:46,960
but that that wasn't successful at the

507
00:18:50,390 --> 00:18:48,640
time um

508
00:18:51,590 --> 00:18:50,400
so i i think they're they're very common

509
00:18:53,750 --> 00:18:51,600
i don't see any reason why they wouldn't

510
00:18:55,350 --> 00:18:53,760
be right based on based on all the

511
00:18:57,270 --> 00:18:55,360
characteristics of of the ridge

512
00:18:59,270 --> 00:18:57,280
transform intersections so i think

513
00:19:00,630 --> 00:18:59,280

that's a good take home right is like

514
00:19:01,909 --> 00:19:00,640
they might be hard to find but there's

515
00:19:03,270 --> 00:19:01,919
probably plenty of them so it's worth

516
00:19:04,789 --> 00:19:03,280
trying

517
00:19:07,750 --> 00:19:04,799
yeah thank you

518
00:19:24,070 --> 00:19:07,760
thank you um our next speaker is antonin

519
00:19:24,080 --> 00:19:27,430
good morning everybody

520
00:19:32,230 --> 00:19:28,470
uh

521
00:19:35,430 --> 00:19:32,240
finishing my phd right now the

522
00:19:38,470 --> 00:19:35,440
manuscript is due tomorrow in paris

523
00:19:40,310 --> 00:19:38,480
uh so yeah probably in advance for the

524
00:19:42,549 --> 00:19:40,320
messiness of this presentation i'm a bit

525
00:19:45,110 --> 00:19:42,559
overwhelmed at the moment but i will try

526
00:19:47,029 --> 00:19:45,120
my best to talk about this project that

527
00:19:50,070 --> 00:19:47,039
i worked on during my phd

528
00:19:53,590 --> 00:19:52,310
which is about using ecological modeling

529
00:19:56,230 --> 00:19:53,600
to constrain

530
00:19:58,470 --> 00:19:56,240
uh the habitability of a potential

531
00:19:59,669 --> 00:19:58,480
hydrothermal environments in enzymatic

532
00:20:03,110 --> 00:19:59,679
ocean

533
00:20:05,029 --> 00:20:03,120
and try to discuss how

534
00:20:12,230 --> 00:20:05,039
such a hypothetical biosphere that could

535
00:20:16,630 --> 00:20:14,710
all right so answer this and uh thank

536
00:20:18,310 --> 00:20:16,640
you dr cable to actually mentioning a

537
00:20:20,630 --> 00:20:18,320
little bit about and so that is sparing

538
00:20:22,549 --> 00:20:20,640

me a few seconds of introduction

539
00:20:25,190 --> 00:20:22,559
but it is this moon that orbits around

540
00:20:27,590 --> 00:20:25,200
saturn most of you know but it has a

541
00:20:31,750 --> 00:20:27,600
liquid water ocean

542
00:20:35,029 --> 00:20:31,760
that is overlaid by a nice layer

543
00:20:37,430 --> 00:20:35,039
that has cracks and a space bloom arrows

544
00:20:40,549 --> 00:20:37,440
from these cracks and this base boom was

545
00:20:42,470 --> 00:20:40,559
visited by the cassini spacecraft

546
00:20:45,029 --> 00:20:42,480
and the cassini spacecraft found in this

547
00:20:48,950 --> 00:20:45,039
room some very interesting gases such as

548
00:20:52,070 --> 00:20:48,960
methane hydrogen and carbon dioxide

549
00:20:53,669 --> 00:20:52,080
and these are evocative of hydrothermal

550
00:20:56,149 --> 00:20:53,679
systems just like the one that was

551
00:20:58,230 --> 00:20:56,159
described by dr kili

552
00:21:00,830 --> 00:20:58,240
uh which is lost city uh hydrotomorrow

553
00:21:03,270 --> 00:21:00,840
so alkaline vents where

554
00:21:04,870 --> 00:21:03,280
separatisation fluid is released in the

555
00:21:07,990 --> 00:21:04,880
ocean

556
00:21:10,470 --> 00:21:08,000
and yeah as mentioned these vents are

557
00:21:11,510 --> 00:21:10,480
populated by microbes such as this one

558
00:21:14,310 --> 00:21:11,520
here

559
00:21:16,390 --> 00:21:14,320
that rely on the conversion of hydrogen

560
00:21:19,590 --> 00:21:16,400
and carbon dioxide into methane

561
00:21:23,510 --> 00:21:21,669
so it is very interesting that uh

562
00:21:25,830 --> 00:21:23,520
enceladus has

563
00:21:28,070 --> 00:21:25,840

you know not only a liquid water ocean

564
00:21:29,830 --> 00:21:28,080
that you know make

565
00:21:32,070 --> 00:21:29,840
makes us think about potential

566
00:21:33,990 --> 00:21:32,080
habitability but it also has a very

567
00:21:37,190 --> 00:21:34,000
specific environment

568
00:21:39,750 --> 00:21:37,200
uh candidate to habitability

569
00:21:42,310 --> 00:21:39,760
uh and not only a candidate environment

570
00:21:43,110 --> 00:21:42,320
but also a candidate type of organism in

571
00:21:44,950 --> 00:21:43,120
these

572
00:21:46,789 --> 00:21:44,960
critters here

573
00:21:48,789 --> 00:21:46,799
so what we did as

574
00:21:51,990 --> 00:21:48,799
uh you know

575
00:21:54,630 --> 00:21:52,000
ecological modeling biologists

576
00:21:56,789 --> 00:21:54,640
we say okay well we'll try to model this

577
00:21:58,630 --> 00:21:56,799
type of organism and

578
00:22:00,710 --> 00:21:58,640
see if we can have a definition of

579
00:22:03,270 --> 00:22:00,720
viability of a population of such

580
00:22:05,190 --> 00:22:03,280
organism that can emerge from a model

581
00:22:06,630 --> 00:22:05,200
and also try to quantify

582
00:22:08,390 --> 00:22:06,640
uh

583
00:22:11,029 --> 00:22:08,400
how much methane would be produced by

584
00:22:12,950 --> 00:22:11,039
such population and try to

585
00:22:14,630 --> 00:22:12,960
to put that

586
00:22:16,870 --> 00:22:14,640
in comparison with the what was measured

587
00:22:19,750 --> 00:22:16,880
by the casino spacecraft

588
00:22:22,950 --> 00:22:19,760

so we went on and designed a model of uh

589
00:22:24,230 --> 00:22:22,960
population uh dynamics where we focused

590
00:22:25,909 --> 00:22:24,240
on the

591
00:22:27,750 --> 00:22:25,919
energy yield of the catabolic reaction

592
00:22:31,110 --> 00:22:27,760
the catabolic reaction is this one right

593
00:22:33,110 --> 00:22:31,120
that produces energy from the cell

594
00:22:37,270 --> 00:22:33,120
now you see that in this model we don't

595
00:22:39,029 --> 00:22:37,280
have a classical way of modeling the

596
00:22:41,190 --> 00:22:39,039
availability of

597
00:22:42,789 --> 00:22:41,200
nutrients and stuff like that we look at

598
00:22:44,549 --> 00:22:42,799
the energy yields from the catabolic

599
00:22:45,909 --> 00:22:44,559
reaction

600
00:22:48,549 --> 00:22:45,919
that's the the variable that is

601
00:22:50,710 --> 00:22:48,559
important to us because these organisms

602
00:22:53,909 --> 00:22:50,720
uh that rely on this type of reaction

603
00:22:55,750 --> 00:22:53,919
have very low energy yield reactions and

604
00:22:57,909 --> 00:22:55,760
and they are very close to thermodynamic

605
00:23:00,630 --> 00:22:57,919
equilibrium

606
00:23:03,029 --> 00:23:00,640
so in modeling that we uh you know input

607
00:23:04,390 --> 00:23:03,039
parameters here that kind of fits uh the

608
00:23:07,590 --> 00:23:04,400
organisms that

609
00:23:09,590 --> 00:23:07,600
such as this one and veto zeus

610
00:23:11,110 --> 00:23:09,600
in order to

611
00:23:13,909 --> 00:23:11,120
have this uh

612
00:23:15,909 --> 00:23:13,919
pattern of uh survivability to

613
00:23:18,310 --> 00:23:15,919

temperature for example here where our

614
00:23:19,190 --> 00:23:18,320
middle strain does not survive above 90

615
00:23:20,549 --> 00:23:19,200
degrees

616
00:23:21,430 --> 00:23:20,559
this is an important point of course

617
00:23:23,190 --> 00:23:21,440
because

618
00:23:26,470 --> 00:23:23,200
uh there might be liquid water at

619
00:23:30,230 --> 00:23:26,480
temperatures above uh the temperature

620
00:23:31,990 --> 00:23:30,240
of uh 122 clues at which

621
00:23:34,830 --> 00:23:32,000
which is the maximum temperature which

622
00:23:38,470 --> 00:23:34,840
we can observe growth so far for any

623
00:23:40,470 --> 00:23:38,480
organism um yeah and then looking at the

624
00:23:42,630 --> 00:23:40,480
population dynamics so the way the

625
00:23:45,750 --> 00:23:42,640
population grows over time

626
00:23:47,590 --> 00:23:45,760
we look at that and we look at the

627
00:23:50,630 --> 00:23:47,600
affinity of the catabolic reaction or

628
00:23:52,710 --> 00:23:50,640
minus the gibbs free energy that is here

629
00:23:55,190 --> 00:23:52,720
and that depends on the abundance the

630
00:23:56,870 --> 00:23:55,200
relative abundance of the hydrogen

631
00:23:59,430 --> 00:23:56,880
methane and carbon dioxide and we see

632
00:24:02,230 --> 00:23:59,440
that as the population grows this energy

633
00:24:04,710 --> 00:24:02,240
yield affinity goes down until a certain

634
00:24:07,110 --> 00:24:04,720
limit at this limit the population is at

635
00:24:09,669 --> 00:24:07,120
a steady state it doesn't grow anymore

636
00:24:11,430 --> 00:24:09,679
it doesn't die off

637
00:24:13,510 --> 00:24:11,440
and this steady state is characterized

638
00:24:16,870 --> 00:24:13,520

by this term in the parentheses here

639
00:24:19,350 --> 00:24:16,880
being zero so the gibbs free energy is

640
00:24:21,110 --> 00:24:19,360
such that everything here is zero this

641
00:24:21,990 --> 00:24:21,120
is interest an interesting point to make

642
00:24:25,110 --> 00:24:22,000
because

643
00:24:27,909 --> 00:24:25,120
if the initial state of the system was

644
00:24:29,430 --> 00:24:27,919
below this affinity then growth wouldn't

645
00:24:30,710 --> 00:24:29,440
have occurred because

646
00:24:32,710 --> 00:24:30,720
uh this term here would have been

647
00:24:35,909 --> 00:24:32,720
negative

648
00:24:38,070 --> 00:24:35,919
in a way that measures the viability of

649
00:24:39,750 --> 00:24:38,080
a population of intelligence such as

650
00:24:40,549 --> 00:24:39,760
those that we have modeled

651
00:24:42,149 --> 00:24:40,559
in

652
00:24:44,710 --> 00:24:42,159
a given environment

653
00:24:47,029 --> 00:24:44,720
so what is left to do

654
00:24:48,549 --> 00:24:47,039
now is to model said environment so here

655
00:24:50,630 --> 00:24:48,559
we

656
00:24:53,510 --> 00:24:50,640
now go into the physical modeling world

657
00:24:55,669 --> 00:24:53,520
and we try to get a completely idealized

658
00:24:56,710 --> 00:24:55,679
version vision of

659
00:24:58,070 --> 00:24:56,720
what

660
00:24:59,669 --> 00:24:58,080
is the environment around the

661
00:25:02,470 --> 00:24:59,679
hydrothermal vents

662
00:25:03,590 --> 00:25:02,480
so we have a hydrothermal fluid here

663
00:25:06,710 --> 00:25:03,600

that is

664
00:25:09,190 --> 00:25:06,720
coming from well the ground and is mixed

665
00:25:11,909 --> 00:25:09,200
with ocean water in the so-called mixing

666
00:25:13,990 --> 00:25:11,919
layer and then this mixing there has you

667
00:25:15,909 --> 00:25:14,000
know some buoyancy because it's warmer

668
00:25:18,870 --> 00:25:15,919
than the rest of the ocean and it starts

669
00:25:21,350 --> 00:25:18,880
rising forming a plume

670
00:25:24,070 --> 00:25:21,360
um and this plume actually is thought to

671
00:25:26,310 --> 00:25:24,080
reach the uh the icy layer in enceladus

672
00:25:29,510 --> 00:25:26,320
because of the way the

673
00:25:31,909 --> 00:25:29,520
uh the ocean of enceladus is probably

674
00:25:35,269 --> 00:25:31,919
not stratified as uh

675
00:25:38,470 --> 00:25:35,279
the oceans that we have on earth are

676
00:25:39,750 --> 00:25:38,480
so then we model our population or

677
00:25:41,029 --> 00:25:39,760
i mean the habitability and the

678
00:25:43,590 --> 00:25:41,039
potentiality

679
00:25:44,950 --> 00:25:43,600
potential population in this idealized

680
00:25:46,630 --> 00:25:44,960
environment

681
00:25:47,990 --> 00:25:46,640
and uh here on this figure we can see

682
00:25:50,070 --> 00:25:48,000
around the hydrogen event how the

683
00:25:51,830 --> 00:25:50,080
concentrations are modified by the

684
00:25:54,789 --> 00:25:51,840
action of a population

685
00:25:56,470 --> 00:25:54,799
the blue line represents hydrogen

686
00:25:58,149 --> 00:25:56,480
which is completely depleted here in

687
00:26:00,950 --> 00:25:58,159
this particular simulation

688
00:26:02,870 --> 00:26:00,960

uh methane is produced in green

689
00:26:05,190 --> 00:26:02,880
and so on and we can connect that to the

690
00:26:07,669 --> 00:26:05,200
composition of the plume that rises

691
00:26:09,830 --> 00:26:07,679
above the mixing layer an important

692
00:26:11,590 --> 00:26:09,840
remark here is that we consider the

693
00:26:14,070 --> 00:26:11,600
population to be fixed in this mixing

694
00:26:14,870 --> 00:26:14,080
layer it does not travel with water that

695
00:26:20,390 --> 00:26:14,880
uh

696
00:26:22,470 --> 00:26:20,400
so as dr kelly mentioned the the

697
00:26:24,549 --> 00:26:22,480
microorganisms that are found in la city

698
00:26:26,870 --> 00:26:24,559
hydrothermal fields are found in

699
00:26:30,390 --> 00:26:26,880
biofilms mostly but they are fixed they

700
00:26:32,789 --> 00:26:31,190
okay

701
00:26:35,029 --> 00:26:32,799
this is just to keep in mind for later

702
00:26:37,669 --> 00:26:35,039
but in the first

703
00:26:40,230 --> 00:26:37,679
project we looked at uh you know how

704
00:26:43,350 --> 00:26:40,240
these modified concentrations could be

705
00:26:45,110 --> 00:26:43,360
uh translated into composition of the uh

706
00:26:47,110 --> 00:26:45,120
space plume and

707
00:26:48,310 --> 00:26:47,120
how we could compare different scenarios

708
00:26:50,470 --> 00:26:48,320
regarding the habitability of the

709
00:26:53,510 --> 00:26:50,480
hydrothermal vents to the measures

710
00:26:55,909 --> 00:26:53,520
carried out by the casino machine

711
00:26:58,390 --> 00:26:55,919
now this work was published last year

712
00:27:00,470 --> 00:26:58,400
so you can look at it

713
00:27:02,149 --> 00:27:00,480

so we simulate these compositions and

714
00:27:04,950 --> 00:27:02,159
these hydrogen events for

715
00:27:06,789 --> 00:27:04,960
quite a wide range of

716
00:27:07,669 --> 00:27:06,799
parameters and conditions

717
00:27:09,350 --> 00:27:07,679
that are

718
00:27:11,430 --> 00:27:09,360
attempting to reproduce you know

719
00:27:13,590 --> 00:27:11,440
uncertainty or variability in the

720
00:27:14,710 --> 00:27:13,600
composition of hydrothermal fluids here

721
00:27:16,470 --> 00:27:14,720
on earth

722
00:27:18,389 --> 00:27:16,480
so you know we take the

723
00:27:20,710 --> 00:27:18,399
hydrogen concentration in hydrothermal

724
00:27:23,350 --> 00:27:20,720
fluids from you know very low to the

725
00:27:25,430 --> 00:27:23,360
maximum in separation experiments and we

726
00:27:28,230 --> 00:27:25,440
do the same for methane for example

727
00:27:29,669 --> 00:27:28,240
and temperature and stuff like that

728
00:27:32,549 --> 00:27:29,679
so here we have distributions of

729
00:27:34,950 --> 00:27:32,559
simulations under three scenarios so the

730
00:27:37,029 --> 00:27:34,960
first one is the blue line here which

731
00:27:37,990 --> 00:27:37,039
represents the uninhabitable

732
00:27:42,470 --> 00:27:38,000
uh

733
00:27:43,909 --> 00:27:42,480
nowhere around the vents

734
00:27:46,070 --> 00:27:43,919
the conditions were right for the

735
00:27:48,470 --> 00:27:46,080
population to grow so these are the blue

736
00:27:49,669 --> 00:27:48,480
ones the orange ones are where the

737
00:27:51,350 --> 00:27:49,679
conditions

738
00:27:53,269 --> 00:27:51,360

somewhere around the vent were found to

739
00:27:55,750 --> 00:27:53,279
be habitable or viable to a population

740
00:27:57,990 --> 00:27:55,760
of methanogens but we just left it a

741
00:27:59,350 --> 00:27:58,000
biotic and then the green one is with

742
00:28:01,830 --> 00:27:59,360
biotic production of methane and

743
00:28:05,110 --> 00:28:01,840
consumption of hydrogen

744
00:28:07,269 --> 00:28:05,120
looking at the distribution for hydrogen

745
00:28:09,029 --> 00:28:07,279
escape rate in the plume compared to the

746
00:28:11,750 --> 00:28:09,039
magenta lines here that are the

747
00:28:13,909 --> 00:28:11,760
observations made by cassini

748
00:28:14,710 --> 00:28:13,919
we see that the observations they match

749
00:28:16,950 --> 00:28:14,720
with

750
00:28:20,310 --> 00:28:16,960
the hypothesis that that might be you

751
00:28:22,470 --> 00:28:20,320
know a hydrothermal environment that is

752
00:28:24,470 --> 00:28:22,480
viable to the moderate population of

753
00:28:27,190 --> 00:28:24,480
methanogens

754
00:28:29,750 --> 00:28:27,200
and not only that but also

755
00:28:32,310 --> 00:28:29,760
the depletion of h2 by the methanogens

756
00:28:33,990 --> 00:28:32,320
is not sufficient in our model to really

757
00:28:36,389 --> 00:28:34,000
make a difference and

758
00:28:38,230 --> 00:28:36,399
it cannot enable us to conclude that

759
00:28:41,029 --> 00:28:38,240
methanogens are unlikely based on the

760
00:28:41,750 --> 00:28:41,039
evidence of h2

761
00:28:44,549 --> 00:28:41,760
so

762
00:28:46,950 --> 00:28:44,559
the observed evidence of h2 to us for

763
00:28:48,870 --> 00:28:46,960

our modeling is compatible with both

764
00:28:51,350 --> 00:28:48,880
habitable conditions but also conditions

765
00:28:52,950 --> 00:28:51,360
where h2 has been depleted by

766
00:28:54,870 --> 00:28:52,960
methanogens

767
00:28:56,789 --> 00:28:54,880
and then looking at methane

768
00:28:59,190 --> 00:28:56,799
the abiotic distributions in blue and

769
00:29:00,630 --> 00:28:59,200
orange they do not match with the

770
00:29:02,070 --> 00:29:00,640
observations

771
00:29:04,310 --> 00:29:02,080
so our modeling suggests that

772
00:29:05,990 --> 00:29:04,320
separatisation which is the only ability

773
00:29:08,070 --> 00:29:06,000
process that we consider here

774
00:29:10,389 --> 00:29:08,080
is not a good explanation for the

775
00:29:11,830 --> 00:29:10,399
methane that was found in the plume

776
00:29:14,950 --> 00:29:11,840
but under the hypothesis of a

777
00:29:18,070 --> 00:29:14,960
methanogenic population the observation

778
00:29:20,070 --> 00:29:18,080
is uh kind of likely right

779
00:29:22,149 --> 00:29:20,080
so based on these quantitative

780
00:29:23,909 --> 00:29:22,159
assessments of production of methane and

781
00:29:25,190 --> 00:29:23,919
consumption of h2

782
00:29:27,510 --> 00:29:25,200
we cannot really

783
00:29:29,350 --> 00:29:27,520
uh discard

784
00:29:31,029 --> 00:29:29,360
based on the cassini data and our

785
00:29:32,870 --> 00:29:31,039
understanding and sympathization discard

786
00:29:35,510 --> 00:29:32,880
the hypothesis that's a methanogenic

787
00:29:38,470 --> 00:29:35,520
population is present

788
00:29:40,310 --> 00:29:38,480

okay but next we looked at how this

789
00:29:42,470 --> 00:29:40,320
population would you know look like in

790
00:29:45,350 --> 00:29:42,480
terms of size and stuff like that so we

791
00:29:46,950 --> 00:29:45,360
try to constrain the total biomass that

792
00:29:48,310 --> 00:29:46,960
would be represented in such a

793
00:29:49,909 --> 00:29:48,320
population

794
00:29:51,990 --> 00:29:49,919
and here we have two distributions so

795
00:29:53,430 --> 00:29:52,000
this one doesn't assume anything

796
00:29:55,830 --> 00:29:53,440
regarding the methane output of the

797
00:29:57,990 --> 00:29:55,840
population and the dotted line

798
00:29:59,669 --> 00:29:58,000
is the distribution under the assumption

799
00:30:01,029 --> 00:29:59,679
that methane in the plume comes

800
00:30:03,190 --> 00:30:01,039
effectively from a population of

801
00:30:05,350 --> 00:30:03,200
methanogens so this is a subset of

802
00:30:08,549 --> 00:30:05,360
populations that produce enough methane

803
00:30:10,630 --> 00:30:08,559
to explain the observation tests

804
00:30:13,269 --> 00:30:10,640
so we find this population uh to be

805
00:30:15,750 --> 00:30:13,279
quite small about the same mass uh in

806
00:30:18,549 --> 00:30:15,760
terms of carbon equivalent to one single

807
00:30:21,350 --> 00:30:18,559
whale orders of magnitude below the

808
00:30:26,789 --> 00:30:21,360
archaea the biosphere kia on earth or

809
00:30:30,149 --> 00:30:28,470
also the important point about the

810
00:30:31,669 --> 00:30:30,159
biomass being fixed so here we are

811
00:30:33,750 --> 00:30:31,679
considering the total biomass which is

812
00:30:35,590 --> 00:30:33,760
you know localized in an environment so

813
00:30:37,590 --> 00:30:35,600

for example this is a representation of

814
00:30:39,669 --> 00:30:37,600
the density of biomass around the fluid

815
00:30:41,190 --> 00:30:39,679
but we are around the hydrothermal vent

816
00:30:44,710 --> 00:30:41,200
but we are interested in what we can

817
00:30:47,110 --> 00:30:44,720
find in potentially find in uh the space

818
00:30:50,070 --> 00:30:47,120
plume and even before that the groom

819
00:30:50,950 --> 00:30:50,080
that rises from the hydrothermal uh

820
00:30:52,950 --> 00:30:50,960
vents

821
00:30:54,710 --> 00:30:52,960
so for that we have to consider the

822
00:30:56,470 --> 00:30:54,720
biomass production because this is the

823
00:30:59,110 --> 00:30:56,480
quantity that scales with whatever can

824
00:31:00,230 --> 00:30:59,120
escape the system

825
00:31:02,630 --> 00:31:00,240
uh

826
00:31:05,750 --> 00:31:02,640
so we computed that as well and see that

827
00:31:06,630 --> 00:31:05,760
the production uh normalized by

828
00:31:13,509 --> 00:31:06,640
the

829
00:31:16,470 --> 00:31:13,519
methane that is found in plume is

830
00:31:18,870 --> 00:31:16,480
quite close to that of hydrothermal

831
00:31:20,870 --> 00:31:18,880
ecosystems on earth

832
00:31:22,630 --> 00:31:20,880
and finally my time is running out so

833
00:31:26,070 --> 00:31:22,640
i'm going to be fast but finally we

834
00:31:27,750 --> 00:31:26,080
would like to constrain you know how uh

835
00:31:29,909 --> 00:31:27,760
how could we

836
00:31:32,870 --> 00:31:29,919
design uh the mission or help this

837
00:31:35,029 --> 00:31:32,880
animation so that the risk of

838
00:31:36,870 --> 00:31:35,039

false negative is constrained what i

839
00:31:38,149 --> 00:31:36,880
mean by that is that

840
00:31:40,710 --> 00:31:38,159
we'd like an instrument to have

841
00:31:43,110 --> 00:31:40,720
sufficient resolution or we'd like to

842
00:31:45,909 --> 00:31:43,120
capture a sufficient sample so that the

843
00:31:47,590 --> 00:31:45,919
risk of not seeing about signatures of

844
00:31:49,430 --> 00:31:47,600
by signature

845
00:31:50,710 --> 00:31:49,440
in the case where a population exists is

846
00:31:52,149 --> 00:31:50,720
minimized

847
00:31:54,310 --> 00:31:52,159
so this is the meaning of this figure

848
00:31:56,789 --> 00:31:54,320
here where we are trying to assessing

849
00:31:59,269 --> 00:31:56,799
the minimal sample volume size that is

850
00:32:00,470 --> 00:31:59,279
required so that if there are cells dead

851
00:32:02,549 --> 00:32:00,480
cells

852
00:32:04,310 --> 00:32:02,559
they are captured and here on the right

853
00:32:06,070 --> 00:32:04,320
side we are looking at a molecular

854
00:32:08,470 --> 00:32:06,080
signature such as glycine that can be

855
00:32:10,070 --> 00:32:08,480
produced a biologically and biotically

856
00:32:11,350 --> 00:32:10,080
and we kind of map the concentrations

857
00:32:13,669 --> 00:32:11,360
that would

858
00:32:15,350 --> 00:32:13,679
be evidence in favor of abiotic

859
00:32:17,190 --> 00:32:15,360
production or in favor of biotic

860
00:32:19,830 --> 00:32:17,200
production

861
00:32:21,990 --> 00:32:19,840
so yeah i'm gonna leave it here and

862
00:32:28,549 --> 00:32:22,000
think thank you very much for listening

863
00:32:28,559 --> 00:32:41,110

um we have time for one question

864
00:32:44,870 --> 00:32:43,029
hello morgan cable jpl great

865
00:32:46,870 --> 00:32:44,880
presentation so

866
00:32:49,669 --> 00:32:46,880
you mentioned that the organisms that

867
00:32:51,430 --> 00:32:49,679
you modeled uh that they just hung out

868
00:32:53,190 --> 00:32:51,440
down at the base of the hydrothermal

869
00:32:56,870 --> 00:32:53,200
vents and they were

870
00:32:59,029 --> 00:32:56,880
wrapped within biofilms so if you were

871
00:33:00,789 --> 00:32:59,039
to search for biosignatures in the plume

872
00:33:01,509 --> 00:33:00,799
it sounds like you would focus more on

873
00:33:04,310 --> 00:33:01,519
the

874
00:33:05,269 --> 00:33:04,320
molecular ones that maybe looking for

875
00:33:07,830 --> 00:33:05,279
you know

876
00:33:09,190 --> 00:33:07,840
cells themselves might not be the right

877
00:33:11,590 --> 00:33:09,200
strategy or can you comment on that a

878
00:33:14,710 --> 00:33:11,600
little bit

879
00:33:17,590 --> 00:33:14,720
thank you for your question so

880
00:33:21,830 --> 00:33:19,509
we enter here uh

881
00:33:23,350 --> 00:33:21,840
some speculation because it is unclear

882
00:33:26,230 --> 00:33:23,360
whether cells

883
00:33:28,470 --> 00:33:26,240
i mean the proportion of dead cells that

884
00:33:31,830 --> 00:33:28,480
can leave the system as cells retaining

885
00:33:34,230 --> 00:33:31,840
the stretch their structure or as uh

886
00:33:36,870 --> 00:33:34,240
or as just you know broken down cells

887
00:33:38,230 --> 00:33:36,880
and molecules

888
00:33:40,549 --> 00:33:38,240

my guess would be that most of these

889
00:33:41,830 --> 00:33:40,559
cells that escape are dead or dying

890
00:33:43,190 --> 00:33:41,840
because they are leaving the the

891
00:33:44,389 --> 00:33:43,200
environment where the conditions are

892
00:33:47,830 --> 00:33:44,399
right for them

893
00:33:49,430 --> 00:33:47,840
yeah that's okay if if they you know get

894
00:33:51,190 --> 00:33:49,440
shot off into space they're probably not

895
00:33:53,269 --> 00:33:51,200
long for this world anyway

896
00:33:54,549 --> 00:33:53,279
yeah yeah anyway

897
00:33:55,909 --> 00:33:54,559
um

898
00:33:57,269 --> 00:33:55,919
so yeah the question

899
00:33:59,509 --> 00:33:57,279
boils down to

900
00:34:00,870 --> 00:33:59,519
kind of guessing whether uh

901
00:34:02,789 --> 00:34:00,880
you know what would be the proportion of

902
00:34:04,950 --> 00:34:02,799
cells that would keep some structure

903
00:34:07,830 --> 00:34:04,960
until the very end or

904
00:34:10,149 --> 00:34:07,840
that would be under biomolecules

905
00:34:12,230 --> 00:34:10,159
to me it sounds

906
00:34:13,829 --> 00:34:12,240
more

907
00:34:14,950 --> 00:34:13,839
cautious to look at molecular based

908
00:34:19,190 --> 00:34:14,960
signatures

909
00:34:21,190 --> 00:34:19,200
even though there have been some papers

910
00:34:22,869 --> 00:34:21,200
suggesting that cells can retain some

911
00:34:24,790 --> 00:34:22,879
structure when they are outgassed in

912
00:34:27,270 --> 00:34:24,800
space

913
00:34:29,669 --> 00:34:27,280

most of them actually don't and

914
00:34:32,790 --> 00:34:29,679
in any way we would only look at broken

915
00:34:34,069 --> 00:34:32,800
down cells and molecular biomolecules

916
00:34:36,310 --> 00:34:34,079
thank you and good luck with your

917
00:34:38,950 --> 00:34:36,320
submission of your thesis tomorrow

918
00:34:48,790 --> 00:34:40,389
we don't really have time for another

919
00:34:53,430 --> 00:34:50,790
thank you for your questions our next

920
00:35:03,270 --> 00:34:53,440
speaker is rabia papal from ex marseille

921
00:35:09,349 --> 00:35:06,150
yes so good morning everyone um i'm a

922
00:35:11,750 --> 00:35:09,359
first year phd student at the

923
00:35:14,150 --> 00:35:11,760
mediterranean institute of oceanography

924
00:35:17,750 --> 00:35:14,160
and today i'm going to talk about

925
00:35:22,790 --> 00:35:17,760
cultivating microbial consortia

926
00:35:28,829 --> 00:35:25,589
so our work is based on the submarine

927
00:35:32,150 --> 00:35:28,839
alkaline vent theory of the origin of

928
00:35:34,710 --> 00:35:32,160
life which focuses on the way a cell

929
00:35:35,990 --> 00:35:34,720
obtains its energy so in these

930
00:35:39,670 --> 00:35:36,000
hydrothermal

931
00:35:42,710 --> 00:35:39,680
we have very steep

932
00:35:45,030 --> 00:35:42,720
redux and ph gradients that create

933
00:35:47,430 --> 00:35:45,040
proton gradients across micro pores in

934
00:35:49,510 --> 00:35:47,440
the chimneys and these proton gradients

935
00:35:50,630 --> 00:35:49,520
are reminiscent of

936
00:35:53,270 --> 00:35:50,640
the

937
00:35:55,910 --> 00:35:53,280
proton motive force that virtually all

938
00:35:57,910 --> 00:35:55,920

known cells use to generate their energy

939
00:36:00,470 --> 00:35:57,920
so we have a link between the inorganic

940
00:36:02,230 --> 00:36:00,480
and the organic here and our team is

941
00:36:03,109 --> 00:36:02,240
trying to understand

942
00:36:05,190 --> 00:36:03,119
the

943
00:36:07,750 --> 00:36:05,200
microbial communities and present day

944
00:36:10,390 --> 00:36:07,760
alkaline hydrothermal systems

945
00:36:11,829 --> 00:36:10,400
to hopefully understand to hopefully

946
00:36:14,470 --> 00:36:11,839
open a window

947
00:36:17,750 --> 00:36:14,480
to the very early microbial communities

948
00:36:19,829 --> 00:36:17,760
on earth and potentially elsewhere

949
00:36:22,790 --> 00:36:19,839
so the driving force at these alkaline

950
00:36:25,190 --> 00:36:22,800
hydrothermal systems is serpentinization

951
00:36:27,190 --> 00:36:25,200
which is the hydration of ultramafic

952
00:36:29,349 --> 00:36:27,200
rock in which creates serpentine

953
00:36:31,190 --> 00:36:29,359
brewside and magnetite and most

954
00:36:32,790 --> 00:36:31,200
importantly a very large amount of

955
00:36:35,750 --> 00:36:32,800
hydrogen gas

956
00:36:37,109 --> 00:36:35,760
it also creates a very alkaline milky

957
00:36:39,670 --> 00:36:37,119
and heat

958
00:36:40,550 --> 00:36:39,680
and the hydrogen cast can further react

959
00:36:42,710 --> 00:36:40,560
with

960
00:36:45,270 --> 00:36:42,720
carbon dioxide from the system in an

961
00:36:47,109 --> 00:36:45,280
abiotic reaction to methane and small

962
00:36:48,470 --> 00:36:47,119
organic molecules

963
00:36:51,990 --> 00:36:48,480

and

964
00:36:54,230 --> 00:36:52,000
yeah so but most of the

965
00:36:56,470 --> 00:36:54,240
co2 that is present in the system is

966
00:36:59,030 --> 00:36:56,480
immediately precipitated in carbonates

967
00:37:01,190 --> 00:36:59,040
because of the very alkaline ph so we

968
00:37:03,829 --> 00:37:01,200
can see that serpentinization creates

969
00:37:06,470 --> 00:37:03,839
very harsh environments for life

970
00:37:09,030 --> 00:37:06,480
however it does provide compounds for

971
00:37:11,109 --> 00:37:09,040
microbial metabolism such as the

972
00:37:14,390 --> 00:37:11,119
hydrogen which can be used as a large

973
00:37:16,870 --> 00:37:14,400
energy source also the methane

974
00:37:18,630 --> 00:37:16,880
a carbon source with formid acetate

975
00:37:21,430 --> 00:37:18,640
other small organic molecules and

976
00:37:23,430 --> 00:37:21,440
methane and the ambient seawater also

977
00:37:26,390 --> 00:37:23,440
supplies a range of potential electron

978
00:37:28,790 --> 00:37:26,400
acceptors most importantly in

979
00:37:31,990 --> 00:37:28,800
modern systems these are oxygen nitrate

980
00:37:34,069 --> 00:37:32,000
sulfate and dissolved carbon

981
00:37:36,230 --> 00:37:34,079
so our team is studying the proney bay

982
00:37:37,910 --> 00:37:36,240
hydrothermal field which is located at

983
00:37:40,710 --> 00:37:37,920
the southern coast of

984
00:37:43,190 --> 00:37:40,720
new caledonia and because the system is

985
00:37:44,790 --> 00:37:43,200
shallow it comprises characteristics of

986
00:37:46,710 --> 00:37:44,800
both terrestrial and marine

987
00:37:49,190 --> 00:37:46,720
serpentinizing systems

988
00:37:51,990 --> 00:37:49,200

so it might we might be eventually able

989
00:37:52,790 --> 00:37:52,000
to use it as a model system

990
00:37:55,349 --> 00:37:52,800
for

991
00:37:57,829 --> 00:37:55,359
other systems that are less accessible

992
00:38:01,030 --> 00:37:57,839
and as you can see here it comprises

993
00:38:02,310 --> 00:38:01,040
terrestrial intertidal and marine sites

994
00:38:03,990 --> 00:38:02,320
and

995
00:38:07,109 --> 00:38:04,000
what makes it special is that the

996
00:38:09,349 --> 00:38:07,119
hydrothermal fluid is of meteoric origin

997
00:38:11,430 --> 00:38:09,359
so we have a steep salinity gradient

998
00:38:14,150 --> 00:38:11,440
between the hydrothermal fluid and the

999
00:38:15,270 --> 00:38:14,160
ambient sea water

1000
00:38:17,190 --> 00:38:15,280
so our

1001
00:38:19,349 --> 00:38:17,200
team is now starting to study the

1002
00:38:21,750 --> 00:38:19,359
metabolic functioning of the microbial

1003
00:38:23,589 --> 00:38:21,760
communities at proney bay but the issue

1004
00:38:25,829 --> 00:38:23,599
with that is that the majority of the

1005
00:38:27,430 --> 00:38:25,839
key players have not been cultivated yet

1006
00:38:28,550 --> 00:38:27,440
so we are lacking the experimental

1007
00:38:29,349 --> 00:38:28,560
evidence

1008
00:38:32,310 --> 00:38:29,359
so

1009
00:38:34,550 --> 00:38:32,320
our aim in this study was to cultivate

1010
00:38:37,829 --> 00:38:34,560
microbial consortium from prony bay for

1011
00:38:40,390 --> 00:38:37,839
the first time and we chose to

1012
00:38:44,390 --> 00:38:40,400
assess their the effect of the electron

1013
00:38:49,510 --> 00:38:47,430

so we were working on samples from 2018

1014
00:38:51,670 --> 00:38:49,520
that were taken from the intertidal site

1015
00:38:53,750 --> 00:38:51,680
at prone bay and we used them to

1016
00:38:55,349 --> 00:38:53,760
inoculate four different uh cultural

1017
00:38:58,069 --> 00:38:55,359
conditions

1018
00:38:59,910 --> 00:38:58,079
in the controlled bioreactors and all of

1019
00:39:02,870 --> 00:38:59,920
these cultural conditions were supplied

1020
00:39:05,030 --> 00:39:02,880
with hydrogen as an energy source with

1021
00:39:07,510 --> 00:39:05,040
both formid and acetate as a carbon

1022
00:39:10,950 --> 00:39:07,520
source and with four different electron

1023
00:39:12,870 --> 00:39:10,960
acceptors being oxygen nitrate sulfate

1024
00:39:14,710 --> 00:39:12,880
and dissolved carbon to promote

1025
00:39:15,750 --> 00:39:14,720
methanogenesis

1026
00:39:18,790 --> 00:39:15,760
and

1027
00:39:21,030 --> 00:39:18,800
yeah our experiments were all at a ph of

1028
00:39:23,589 --> 00:39:21,040
10 and at a temperature of 35 degrees

1029
00:39:27,270 --> 00:39:23,599
celsius and we maintained them over a

1030
00:39:29,589 --> 00:39:27,280
period of two to four weeks

1031
00:39:32,950 --> 00:39:29,599
um and after this period we conducted

1032
00:39:34,790 --> 00:39:32,960
analysis so we conducted hplc to follow

1033
00:39:36,550 --> 00:39:34,800
the consumption of both formidant

1034
00:39:38,950 --> 00:39:36,560
acetate over time

1035
00:39:41,270 --> 00:39:38,960
um ic to follow the consumption of

1036
00:39:43,589 --> 00:39:41,280
nitrate and sulfate and we performed

1037
00:39:46,150 --> 00:39:43,599
meta bar coding to assess the changes in

1038
00:39:48,470 --> 00:39:46,160

community structure over time and we are

1039
00:39:53,829 --> 00:39:48,480
also working on the meta genome and meta

1040
00:39:58,390 --> 00:39:55,670
so in all of our culture conditions we

1041
00:40:00,230 --> 00:39:58,400
saw considerable growth and what was

1042
00:40:02,390 --> 00:40:00,240
interesting is was that the growth

1043
00:40:03,910 --> 00:40:02,400
really reflected the potential energy

1044
00:40:05,990 --> 00:40:03,920
for hydrogen

1045
00:40:08,390 --> 00:40:06,000
oxidation with the respective electron

1046
00:40:10,870 --> 00:40:08,400
receptors so we had most growth in the

1047
00:40:13,349 --> 00:40:10,880
culture grown on aerobic respiration

1048
00:40:18,150 --> 00:40:13,359
followed by nitrate reduction sulfate

1049
00:40:21,829 --> 00:40:19,829
for the consumption of the carbon source

1050
00:40:24,069 --> 00:40:21,839
we could see that both acetate and

1051
00:40:26,230 --> 00:40:24,079
formate were consumed

1052
00:40:27,990 --> 00:40:26,240
however we could not really establish a

1053
00:40:29,349 --> 00:40:28,000
clear preference for either of the

1054
00:40:31,349 --> 00:40:29,359
compounds so

1055
00:40:33,990 --> 00:40:31,359
yeah this question remains open for the

1056
00:40:37,589 --> 00:40:36,150
for the electron acceptors

1057
00:40:38,550 --> 00:40:37,599
so

1058
00:40:40,390 --> 00:40:38,560
conditions

1059
00:40:42,230 --> 00:40:40,400
you can see here um

1060
00:40:44,950 --> 00:40:42,240
sulphate on the secondary axis and it

1061
00:40:47,030 --> 00:40:44,960
was not really consumed at all however

1062
00:40:49,190 --> 00:40:47,040
something else was consumed and that was

1063
00:40:50,630 --> 00:40:49,200

a theosulfate which was a compound of

1064
00:40:52,870 --> 00:40:50,640
the base media

1065
00:40:55,190 --> 00:40:52,880
and we can also see a production of

1066
00:40:58,309 --> 00:40:55,200
sulfites so this consortium would seem

1067
00:40:59,910 --> 00:40:58,319
to uh prefer thiosulfate theosulfates

1068
00:41:01,430 --> 00:40:59,920
over sulfite

1069
00:41:03,190 --> 00:41:01,440
and um

1070
00:41:05,829 --> 00:41:03,200
here in the nitride reducing conditions

1071
00:41:07,910 --> 00:41:05,839
we can see that nitrate was equimolarly

1072
00:41:11,270 --> 00:41:07,920
reduced to nitrite so we have an

1073
00:41:14,230 --> 00:41:11,280
incomplete denitrification

1074
00:41:16,550 --> 00:41:14,240
so moving on to the bacterial diversity

1075
00:41:19,750 --> 00:41:16,560
to the left you can see the diversity of

1076
00:41:21,349 --> 00:41:19,760
the inoculum so the natural community

1077
00:41:23,910 --> 00:41:21,359
and to the right you can see the

1078
00:41:25,030 --> 00:41:23,920
diversity in three of the four cultural

1079
00:41:27,349 --> 00:41:25,040
conditions

1080
00:41:29,910 --> 00:41:27,359
and you can see that only a very

1081
00:41:31,510 --> 00:41:29,920
particular part of the community was

1082
00:41:33,349 --> 00:41:31,520
enriched and

1083
00:41:35,109 --> 00:41:33,359
when we look if we look at the shannon

1084
00:41:37,109 --> 00:41:35,119
index we can see that

1085
00:41:39,270 --> 00:41:37,119
most of the natural diversity was

1086
00:41:41,829 --> 00:41:39,280
retained in the sulfate reducing

1087
00:41:43,829 --> 00:41:41,839
condition or in our case the theosulfate

1088
00:41:45,910 --> 00:41:43,839

reducing condition

1089
00:41:48,309 --> 00:41:45,920
and uh yeah this might point to the

1090
00:41:51,910 --> 00:41:48,319
significance of theosulfates as an

1091
00:41:54,230 --> 00:41:51,920
electron acceptor in the natural system

1092
00:41:56,470 --> 00:41:54,240
other than that we mainly enriched

1093
00:41:59,030 --> 00:41:56,480
serpentinomonas which is really a marker

1094
00:42:01,510 --> 00:41:59,040
species of serpentinizing environments

1095
00:42:03,670 --> 00:42:01,520
and one of the most alkalify organisms

1096
00:42:05,990 --> 00:42:03,680
that we know of

1097
00:42:07,910 --> 00:42:06,000
and we also enriched a large proportion

1098
00:42:10,550 --> 00:42:07,920
of anaerobacillus especially in the

1099
00:42:12,069 --> 00:42:10,560
theosulfate reducing condition

1100
00:42:13,990 --> 00:42:12,079
whereas it's important to know that the

1101
00:42:15,270 --> 00:42:14,000
species of anaerobacilli here was

1102
00:42:19,190 --> 00:42:15,280
different from the species of

1103
00:42:23,750 --> 00:42:21,190
so here you can see again that there is

1104
00:42:25,670 --> 00:42:23,760
a huge taxonomic overlap between the

1105
00:42:28,390 --> 00:42:25,680
oxygen reducing condition and the

1106
00:42:30,790 --> 00:42:28,400
nitrate reducing condition whereas the

1107
00:42:32,870 --> 00:42:30,800
theosulfite reducing condition is really

1108
00:42:36,230 --> 00:42:32,880
different probably due to the lack of

1109
00:42:40,710 --> 00:42:38,230
we also had a look at the archaeal

1110
00:42:42,950 --> 00:42:40,720
diversity but the archaeal abundance was

1111
00:42:45,190 --> 00:42:42,960
way lower than the bacterial one which

1112
00:42:46,390 --> 00:42:45,200
is quite typical for serpentinizing

1113
00:42:48,309 --> 00:42:46,400

systems

1114
00:42:51,349 --> 00:42:48,319
and you can see that we almost

1115
00:42:54,630 --> 00:42:51,359
exclusively enriched methanogens and

1116
00:42:57,109 --> 00:42:54,640
what is quite exciting is that we were

1117
00:42:58,430 --> 00:42:57,119
able to observe two

1118
00:42:59,990 --> 00:42:58,440
species of

1119
00:43:02,710 --> 00:43:00,000
methanosarcianalis that are really

1120
00:43:04,950 --> 00:43:02,720
endemic to serpentinizing systems which

1121
00:43:07,829 --> 00:43:04,960
were the lost city with fenusarcinalis

1122
00:43:09,829 --> 00:43:07,839
and uh the cedars methanosarcinalis

1123
00:43:12,550 --> 00:43:09,839
and we have been trying to cultivate

1124
00:43:15,109 --> 00:43:12,560
them for more than 20 years so it would

1125
00:43:19,829 --> 00:43:15,119
be really cool if we were able to

1126
00:43:24,390 --> 00:43:22,309
so um the consortia that we cultivated

1127
00:43:27,910 --> 00:43:24,400
might actually play a key role in the

1128
00:43:30,150 --> 00:43:27,920
natural system so here you can see a

1129
00:43:31,829 --> 00:43:30,160
theory that was postulated by lang and

1130
00:43:34,790 --> 00:43:31,839
bracelet

1131
00:43:36,790 --> 00:43:34,800
on how the microbial communities and

1132
00:43:39,030 --> 00:43:36,800
serpentinizing systems are able to

1133
00:43:41,910 --> 00:43:39,040
overcome the extreme limitation of

1134
00:43:42,710 --> 00:43:41,920
dissolved inorganic carbon in the system

1135
00:43:45,109 --> 00:43:42,720
and

1136
00:43:47,670 --> 00:43:45,119
according to this theory our consortia

1137
00:43:50,710 --> 00:43:47,680
are part of a consortium of foundation

1138
00:43:53,910 --> 00:43:50,720

species that are able to grow on small

1139
00:43:56,870 --> 00:43:53,920
organic molecules such as carbon formats

1140
00:43:58,309 --> 00:43:56,880
and acetate and transform it into carbon

1141
00:44:00,309 --> 00:43:58,319
dioxides

1142
00:44:03,190 --> 00:44:00,319
which can then be used by a larger and

1143
00:44:05,349 --> 00:44:03,200
more diverse community of autotrophs

1144
00:44:07,349 --> 00:44:05,359
which in turn

1145
00:44:09,829 --> 00:44:07,359
support a different community of

1146
00:44:12,390 --> 00:44:09,839
heterotrophs which end up remineralizing

1147
00:44:14,630 --> 00:44:12,400
uh the co2

1148
00:44:17,030 --> 00:44:14,640
and then bracelet they really underlined

1149
00:44:19,190 --> 00:44:17,040
the significance of sulfate as an

1150
00:44:20,829 --> 00:44:19,200
electron acceptor within the foundation

1151
00:44:24,069 --> 00:44:20,839
species

1152
00:44:26,309 --> 00:44:24,079
um however since our consortium seemed

1153
00:44:28,710 --> 00:44:26,319
to prefer theosulfate it would be really

1154
00:44:31,430 --> 00:44:28,720
interesting uh to assess theosulfate

1155
00:44:34,870 --> 00:44:31,440
reduction and disproportionation

1156
00:44:36,630 --> 00:44:34,880
in the system especially because it is

1157
00:44:39,430 --> 00:44:36,640
very likely that theo sulfate was

1158
00:44:41,109 --> 00:44:39,440
abundant at alkaline hydrothermal vents

1159
00:44:43,990 --> 00:44:41,119
in the hedian

1160
00:44:45,349 --> 00:44:44,000
whereas sulfate was most likely not so

1161
00:44:49,349 --> 00:44:45,359
yet that would be

1162
00:44:54,790 --> 00:44:52,470
so uh to conclude we were able to

1163
00:44:57,349 --> 00:44:54,800

successfully enrich proni bay

1164
00:44:59,910 --> 00:44:57,359
hydrothermal field microbial communities

1165
00:45:02,069 --> 00:44:59,920
on four different electron acceptors

1166
00:45:04,630 --> 00:45:02,079
we were able to measure their metabolic

1167
00:45:06,470 --> 00:45:04,640
activity monitoring theosulfate and

1168
00:45:08,630 --> 00:45:06,480
nitrate reduction

1169
00:45:11,430 --> 00:45:08,640
however something remained unclear and

1170
00:45:14,630 --> 00:45:11,440
that was the carbon source

1171
00:45:16,790 --> 00:45:14,640
we were enriching a very particular part

1172
00:45:18,870 --> 00:45:16,800
of the natural community

1173
00:45:21,030 --> 00:45:18,880
as well um especially uh serpentine

1174
00:45:23,430 --> 00:45:21,040
nominals and anaerobasili

1175
00:45:25,390 --> 00:45:23,440
and potentially some previously

1176
00:45:27,109 --> 00:45:25,400
uncultivated strains of

1177
00:45:29,190 --> 00:45:27,119
methanosarcinalis

1178
00:45:31,670 --> 00:45:29,200
and a theosulfate reduction might

1179
00:45:34,630 --> 00:45:31,680
actually play a key role in the

1180
00:45:37,430 --> 00:45:34,640
foundation species consortia

1181
00:45:39,670 --> 00:45:37,440
so our next step will be to assess the

1182
00:45:41,589 --> 00:45:39,680
question that remains open in these

1183
00:45:45,670 --> 00:45:41,599
experiments which is the question of the

1184
00:45:47,990 --> 00:45:45,680
carbon source so we have previewed a new

1185
00:45:49,910 --> 00:45:48,000
series of cultivation experiments in

1186
00:45:51,910 --> 00:45:49,920
which we will follow the

1187
00:45:54,390 --> 00:45:51,920
consumption of the carbon source using

1188
00:45:59,589 --> 00:45:54,400

stable isotope probing coupled with

1189
00:46:04,470 --> 00:46:02,470
so thank you very much um for giving me

1190
00:46:07,109 --> 00:46:04,480
the opportunity to present today i would

1191
00:46:09,190 --> 00:46:07,119
like to thank paulie stoop who produced

1192
00:46:11,109 --> 00:46:09,200
these results um

1193
00:46:15,990 --> 00:46:11,119
in the frame of an internship

1194
00:46:17,910 --> 00:46:16,000
my phd advisors um and dr anthoustek and

1195
00:46:21,540 --> 00:46:17,920
the rest of the team and

1196
00:46:21,550 --> 00:46:27,030
[Applause]

1197
00:46:27,040 --> 00:46:32,950
we have time for questions

1198
00:46:37,270 --> 00:46:35,589
hi uh julie huber from woods hall that

1199
00:46:38,710 --> 00:46:37,280
was a great talk it's so exciting i'm

1200
00:46:39,910 --> 00:46:38,720
really jealous about your bioreactors

1201
00:46:41,829 --> 00:46:39,920
they're beautiful

1202
00:46:44,550 --> 00:46:41,839
um i was curious it looks like in the

1203
00:46:46,150 --> 00:46:44,560
bacteria you're really enriching for

1204
00:46:48,069 --> 00:46:46,160
groups that are have only been described

1205
00:46:49,270 --> 00:46:48,079
from terrestrial serpentinizing

1206
00:46:52,230 --> 00:46:49,280
environments is that correct

1207
00:46:54,390 --> 00:46:52,240
serpentimonus has only been from

1208
00:46:56,069 --> 00:46:54,400
land-based environments versus your

1209
00:46:59,190 --> 00:46:56,079
archaea which looks similar to some

1210
00:47:01,829 --> 00:46:59,200
marine groups is that right

1211
00:47:03,910 --> 00:47:01,839
uh i'm pretty sure that um some of our

1212
00:47:07,109 --> 00:47:03,920
groups that we enriched uh can also be

1213
00:47:07,910 --> 00:47:07,119

found in found in marine environments um

1214
00:47:10,150 --> 00:47:07,920
so

1215
00:47:12,150 --> 00:47:10,160
it really shows that prony bay has uh

1216
00:47:14,790 --> 00:47:12,160
the characteristics of both terrestrial

1217
00:47:16,870 --> 00:47:14,800
and marine sites so yeah it is really

1218
00:47:18,150 --> 00:47:16,880
sort of a hybrid system which is pretty

1219
00:47:23,030 --> 00:47:18,160
cool

1220
00:47:27,510 --> 00:47:25,430
hi fabia sandra some bmsis i loved your

1221
00:47:29,910 --> 00:47:27,520
growth experiments super cool super cool

1222
00:47:32,150 --> 00:47:29,920
talk i was wondering if you i may have

1223
00:47:33,430 --> 00:47:32,160
missed that plot the consumption rate or

1224
00:47:35,030 --> 00:47:33,440
production rate of methane versus

1225
00:47:36,790 --> 00:47:35,040
concentration curve to get at some of

1226
00:47:41,030 --> 00:47:36,800
the enzymatic

1227
00:47:43,270 --> 00:47:41,040
parameters of methanogenesis

1228
00:47:45,430 --> 00:47:43,280
uh sorry could you repeat the question

1229
00:47:47,510 --> 00:47:45,440
i was wondering if you uh in your growth

1230
00:47:48,790 --> 00:47:47,520
experiments plotted the

1231
00:47:50,309 --> 00:47:48,800
methane production rate versus

1232
00:47:53,190 --> 00:47:50,319
concentration or

1233
00:47:55,270 --> 00:47:53,200
to get enzymatic parameters

1234
00:47:57,510 --> 00:47:55,280
uh no we did not do that what we would

1235
00:47:59,430 --> 00:47:57,520
love to follow um the production of

1236
00:48:01,589 --> 00:47:59,440
methane um so in this series of

1237
00:48:04,870 --> 00:48:01,599
experiments we were uh not able to do

1238
00:48:06,630 --> 00:48:04,880

that but uh we are really hoping that um

1239
00:48:09,109 --> 00:48:06,640
yeah in the next series of experiments

1240
00:48:12,630 --> 00:48:09,119
we can

1241
00:48:12,640 --> 00:48:24,790
we have time for one more question

1242
00:48:29,990 --> 00:48:27,910
okay thank you ravia our next speaker is

1243
00:48:49,430 --> 00:48:30,000
dr alexis templeton from the university

1244
00:48:49,440 --> 00:49:09,430
first in-person speaker

1245
00:49:12,790 --> 00:49:11,270
all right thank you i'm going to be

1246
00:49:15,109 --> 00:49:12,800
talking today a little bit of an

1247
00:49:17,750 --> 00:49:15,119
integration or synthesis of work we've

1248
00:49:20,069 --> 00:49:17,760
been doing in the oman ophelite as a

1249
00:49:21,589 --> 00:49:20,079
terrestrial analog for both ocean worlds

1250
00:49:23,349 --> 00:49:21,599
but as i'm going to talk about in ways

1251
00:49:26,069 --> 00:49:23,359
that i think are connected to mars and

1252
00:49:28,390 --> 00:49:26,079
some of the recent discoveries as well

1253
00:49:29,510 --> 00:49:28,400
and in this work it's going to be some

1254
00:49:31,349 --> 00:49:29,520
aspects of

1255
00:49:33,829 --> 00:49:31,359
science that was done through the rock

1256
00:49:35,910 --> 00:49:33,839
powered life nasa astrobiology institute

1257
00:49:38,790 --> 00:49:35,920
and in close collaboration with the oman

1258
00:49:42,549 --> 00:49:40,950
so i'll start with these cartoons in

1259
00:49:43,750 --> 00:49:42,559
many ways when asked to give a talk in

1260
00:49:46,069 --> 00:49:43,760
this session

1261
00:49:48,150 --> 00:49:46,079
my focus starts over here in our

1262
00:49:50,390 --> 00:49:48,160
different perspectives of hydrothermal

1263
00:49:51,670 --> 00:49:50,400

processes on the rocky crust devotion

1264
00:49:52,790 --> 00:49:51,680
worlds

1265
00:49:54,230 --> 00:49:52,800
and i want to

1266
00:49:56,549 --> 00:49:54,240
talk about the fact that today i'm going

1267
00:49:58,710 --> 00:49:56,559
to often speak to non-hydrothermal

1268
00:50:01,270 --> 00:49:58,720
conditions so not necessarily where a

1269
00:50:03,109 --> 00:50:01,280
heat source is but just the pervasive

1270
00:50:05,030 --> 00:50:03,119
chemical reactions and habitability

1271
00:50:06,710 --> 00:50:05,040
that's generated from ultramafic rocks

1272
00:50:09,829 --> 00:50:06,720
reacting with cool fluids in these

1273
00:50:11,030 --> 00:50:09,839
systems away from those heat sources

1274
00:50:13,030 --> 00:50:11,040
and that's why i also think it's

1275
00:50:14,870 --> 00:50:13,040
relevant in mars often when you see a

1276
00:50:16,230 --> 00:50:14,880
cartoon of the subsurface of mars where

1277
00:50:18,150 --> 00:50:16,240
we think there may be groundwater

1278
00:50:20,150 --> 00:50:18,160
storage and in contact with olivine rich

1279
00:50:21,589 --> 00:50:20,160
rocks there's a sense that water rock

1280
00:50:24,549 --> 00:50:21,599
reactions can produce things like

1281
00:50:26,150 --> 00:50:24,559
molecular hydrogen as electron donor

1282
00:50:28,150 --> 00:50:26,160
but we know that there's a lot of

1283
00:50:30,470 --> 00:50:28,160
olivine rich pathologies very close to

1284
00:50:32,150 --> 00:50:30,480
the surface of mars and the potential

1285
00:50:33,910 --> 00:50:32,160
for their interaction with water and to

1286
00:50:35,910 --> 00:50:33,920
create conditions that are conducive and

1287
00:50:37,510 --> 00:50:35,920
habitable for alkaline vent type

1288
00:50:40,630 --> 00:50:37,520

chemistries i think is very prevalent

1289
00:50:43,109 --> 00:50:40,640
there as well

1290
00:50:45,510 --> 00:50:43,119
so this is the oman ophelia system

1291
00:50:47,670 --> 00:50:45,520
it's a very large exposure of ultramafic

1292
00:50:49,510 --> 00:50:47,680
rocks rich in minerals such as olivine

1293
00:50:51,510 --> 00:50:49,520
and pyroxene

1294
00:50:53,349 --> 00:50:51,520
and in these types of systems we're

1295
00:50:55,190 --> 00:50:53,359
really looking at fluids that are near

1296
00:50:58,069 --> 00:50:55,200
surface temperatures there's no heat

1297
00:51:00,150 --> 00:50:58,079
source or tectonic activity currently

1298
00:51:03,190 --> 00:51:00,160
but there's extensive hydration of these

1299
00:51:05,349 --> 00:51:03,200
rocks and it does lead to the pervasive

1300
00:51:06,950 --> 00:51:05,359
generation of both alkaline and hyper

1301
00:51:08,710 --> 00:51:06,960
alkaline fluids

1302
00:51:10,790 --> 00:51:08,720
and in the places where we can actually

1303
00:51:12,630 --> 00:51:10,800
see the water expressed which often is

1304
00:51:15,030 --> 00:51:12,640
in a seep type environment in this kind

1305
00:51:17,190 --> 00:51:15,040
of context those fluids that range from

1306
00:51:19,910 --> 00:51:17,200
ph's of 9 to 11 are very high in

1307
00:51:22,549 --> 00:51:19,920
hydrogen methane and ammonia so again

1308
00:51:24,870 --> 00:51:22,559
the sense that you can see that state

1309
00:51:25,829 --> 00:51:24,880
generated at lower temperatures and for

1310
00:51:27,349 --> 00:51:25,839
example if you want to look at the

1311
00:51:29,030 --> 00:51:27,359
modeling of the kind of chemistry of

1312
00:51:31,190 --> 00:51:29,040
these fluids or some of the biology of

1313
00:51:32,630 --> 00:51:31,200

who lives in these seeps everett shocks

1314
00:51:34,549 --> 00:51:32,640
group has done a really beautiful body

1315
00:51:35,990 --> 00:51:34,559
of work on this

1316
00:51:37,750 --> 00:51:36,000
what i'm going to talk about today is

1317
00:51:39,910 --> 00:51:37,760
when we look at the surface environment

1318
00:51:42,150 --> 00:51:39,920
that's particularly dry other than these

1319
00:51:43,349 --> 00:51:42,160
few indicators of where fluids are are

1320
00:51:46,150 --> 00:51:43,359
escaping

1321
00:51:48,710 --> 00:51:46,160
the deeper system is incredibly wet it's

1322
00:51:50,870 --> 00:51:48,720
storing massive volumes of water and

1323
00:51:52,790 --> 00:51:50,880
it's not only habitable but highly

1324
00:51:54,150 --> 00:51:52,800
inhabited

1325
00:51:55,990 --> 00:51:54,160
and the way we've been looking at this

1326
00:51:57,430 --> 00:51:56,000
is through the partnership with the oman

1327
00:51:59,670 --> 00:51:57,440
drilling project we've been able to

1328
00:52:02,069 --> 00:51:59,680
establish a series of boreholes that

1329
00:52:05,349 --> 00:52:02,079
range usually from 300 to 400 meters in

1330
00:52:07,270 --> 00:52:05,359
depth that poke in and penetrate across

1331
00:52:08,710 --> 00:52:07,280
all sorts of different windows into the

1332
00:52:10,390 --> 00:52:08,720
subsurface

1333
00:52:11,990 --> 00:52:10,400
ultramafic system

1334
00:52:13,910 --> 00:52:12,000
and sometimes those holes were drilled

1335
00:52:15,589 --> 00:52:13,920
just to give access to the fluids that

1336
00:52:17,829 --> 00:52:15,599
are circulating there and at times we're

1337
00:52:19,589 --> 00:52:17,839
able to do core recovery with excellent

1338
00:52:21,750 --> 00:52:19,599

core recovery with bringing back more

1339
00:52:22,870 --> 00:52:21,760
than a kilometer of core from subsurface

1340
00:52:24,549 --> 00:52:22,880
environments

1341
00:52:26,150 --> 00:52:24,559
and the beauty is that we can pair off

1342
00:52:27,829 --> 00:52:26,160
in the chemistry in the mineralogy of

1343
00:52:29,430 --> 00:52:27,839
those cores against what we see in the

1344
00:52:32,150 --> 00:52:29,440
fluid system in the alkaline fluid

1345
00:52:34,150 --> 00:52:32,160
chemistries

1346
00:52:36,309 --> 00:52:34,160
so i had to show something we don't have

1347
00:52:38,309 --> 00:52:36,319
an alkaline vent so this is me throwing

1348
00:52:39,910 --> 00:52:38,319
a gopro down a well

1349
00:52:42,630 --> 00:52:39,920
i literally have it attached to a

1350
00:52:44,870 --> 00:52:42,640
fishing line i had to duct tape a

1351
00:52:46,870 --> 00:52:44,880
flashlight onto it

1352
00:52:49,109 --> 00:52:46,880
but what i hope you can see here is

1353
00:52:50,150 --> 00:52:49,119
we're in water i we hit water within

1354
00:52:51,670 --> 00:52:50,160
meters

1355
00:52:53,670 --> 00:52:51,680
and we're going down and you're seeing

1356
00:52:56,150 --> 00:52:53,680
the flocks of material of particulates

1357
00:52:57,670 --> 00:52:56,160
of microbial biomass and mineral

1358
00:52:59,589 --> 00:52:57,680
particles that are present in these

1359
00:53:01,829 --> 00:52:59,599
fluids that are circulating

1360
00:53:04,069 --> 00:53:01,839
and we have a highly fractured rock

1361
00:53:08,230 --> 00:53:04,079
system here with transmissivity of

1362
00:53:13,270 --> 00:53:09,750
wow

1363
00:53:13,280 --> 00:53:16,790

it's stable but it looks like

1364
00:53:19,750 --> 00:53:18,309
you don't have one and so i hope they'll

1365
00:53:21,190 --> 00:53:19,760
settle it down just because i'd really

1366
00:53:22,950 --> 00:53:21,200
like to walk through what these chemical

1367
00:53:25,190 --> 00:53:22,960
profiles look like when we're able to go

1368
00:53:32,790 --> 00:53:25,200
down into the subsurface at night so

1369
00:53:37,670 --> 00:53:35,030
it did come back i still own the gopro i

1370
00:53:41,190 --> 00:53:39,109
and of course there's such things as i'm

1371
00:53:43,430 --> 00:53:41,200
waiting for them to fix that as a good

1372
00:53:44,950 --> 00:53:43,440
borehole televiewers and things like

1373
00:53:46,710 --> 00:53:44,960
that but when we first started working i

1374
00:53:48,870 --> 00:53:46,720
just didn't have that equipment and we

1375
00:53:51,109 --> 00:53:48,880
wanted to see what we were we were

1376
00:53:56,069 --> 00:53:51,119
starting to send pumps down into or

1377
00:53:57,030 --> 00:53:56,079
other instrumentation to to collect data

1378
00:54:00,069 --> 00:53:57,040
i mean

1379
00:54:03,510 --> 00:54:00,079
you you want to reload the presentation

1380
00:54:06,630 --> 00:54:04,470
okay

1381
00:54:10,950 --> 00:54:06,640
yeah there's some presentation

1382
00:54:15,829 --> 00:54:12,870
hopefully going past the gopro movie

1383
00:54:22,069 --> 00:54:15,839
doesn't instigate that again all right

1384
00:54:27,190 --> 00:54:24,470
yeah i can't hear you i'm sorry

1385
00:54:35,430 --> 00:54:27,200
this is what's shown on the screen okay

1386
00:54:40,069 --> 00:54:38,789
i could go give dan tolman's talk

1387
00:54:42,630 --> 00:54:40,079
which is going to be very good by the

1388
00:54:44,789 --> 00:54:42,640

way with about the acetogens in this

1389
00:54:50,829 --> 00:54:44,799
system i'm

1390
00:55:04,549 --> 00:54:53,910
to great okay

1391
00:55:09,670 --> 00:55:07,349
maybe minimize the presentation view so

1392
00:55:11,270 --> 00:55:09,680
it's just the slot

1393
00:55:44,950 --> 00:55:11,280
yeah i don't

1394
00:55:58,710 --> 00:55:46,470
okay so

1395
00:55:58,720 --> 00:56:03,910
30 seconds

1396
00:56:03,920 --> 00:56:08,150
after a year i'm seeing teaching

1397
00:56:08,160 --> 00:56:23,109
we will come back

1398
00:56:27,030 --> 00:56:26,069
that's it right

1399
00:56:28,710 --> 00:56:27,040
uh

1400
00:56:30,630 --> 00:56:28,720
no that's the next talk it's this

1401
00:56:35,349 --> 00:56:30,640
morning it's this one right here

1402
00:56:38,309 --> 00:56:36,390
yeah

1403
00:56:40,150 --> 00:56:38,319
perfect how are you gonna go to the

1404
00:56:41,910 --> 00:56:40,160
necklace how do we get it projected onto

1405
00:56:45,270 --> 00:56:41,920
the screen as soon as i unlock the

1406
00:56:50,390 --> 00:56:46,789
i think the moral of the stories they

1407
00:56:51,990 --> 00:56:50,400
just want dan coleman's talk to come up

1408
00:56:53,349 --> 00:56:52,000
so please stay tuned for that in just a

1409
00:57:15,109 --> 00:56:53,359
minute and i think

1410
00:57:15,119 --> 00:57:38,549
showing overlay

1411
00:57:42,950 --> 00:57:41,589
maybe just felt through it and

1412
00:57:47,430 --> 00:57:42,960
i'm trying to get it to

1413
00:57:50,390 --> 00:57:49,510

okay wow

1414
00:57:52,069 --> 00:57:50,400
all right

1415
00:57:54,069 --> 00:57:52,079
well

1416
00:57:55,829 --> 00:57:54,079
in order to move forward i please ignore

1417
00:57:57,750 --> 00:57:55,839
the data up here i just want to talk for

1418
00:57:59,190 --> 00:57:57,760
a moment about what was on that previous

1419
00:58:00,230 --> 00:57:59,200
slide apparently i'm not supposed to

1420
00:58:01,270 --> 00:58:00,240
reveal

1421
00:58:05,510 --> 00:58:01,280
the

1422
00:58:07,589 --> 00:58:05,520
subsurface and it's spectacular it's

1423
00:58:09,829 --> 00:58:07,599
only partially shown here

1424
00:58:11,510 --> 00:58:09,839
so when we go to these down hole

1425
00:58:13,510 --> 00:58:11,520
profiles in these boreholes the thing

1426
00:58:16,630 --> 00:58:13,520
that we observe is essentially that we

1427
00:58:19,349 --> 00:58:16,640
can move over almost a volt and in

1428
00:58:20,870 --> 00:58:19,359
electrochemical potential but over you

1429
00:58:22,630 --> 00:58:20,880
know we might go hundreds of meters but

1430
00:58:24,230 --> 00:58:22,640
those transitions happen over the span

1431
00:58:27,510 --> 00:58:24,240
of just a few meters so we're often

1432
00:58:30,390 --> 00:58:27,520
going from 200 or 300 millivolts to

1433
00:58:31,750 --> 00:58:30,400
minus 700 or or close there we're

1434
00:58:33,109 --> 00:58:31,760
sitting right at the lower stability

1435
00:58:35,270 --> 00:58:33,119
limit of water

1436
00:58:36,789 --> 00:58:35,280
similarly those same chemical gradients

1437
00:58:38,150 --> 00:58:36,799
are established we're looking at ph

1438
00:58:41,510 --> 00:58:38,160

variations that are usually going from

1439
00:58:43,990 --> 00:58:41,520
about eight up to about above 11. and

1440
00:58:45,990 --> 00:58:44,000
the transition is a little bit broader

1441
00:58:48,069 --> 00:58:46,000
there in terms of maybe tens of meters

1442
00:58:49,109 --> 00:58:48,079
over which we see those ph variations

1443
00:58:50,549 --> 00:58:49,119
happen

1444
00:58:53,589 --> 00:58:50,559
and when you look at the deeper

1445
00:58:58,870 --> 00:58:57,270
systems down at 2 300 and 400 meters

1446
00:59:01,109 --> 00:58:58,880
this is where we have highly reducing

1447
00:59:03,510 --> 00:59:01,119
conditions maintained and millimolar

1448
00:59:05,510 --> 00:59:03,520
concentrations of hydrogen and methane

1449
00:59:07,670 --> 00:59:05,520
there's very low water rock ratios that

1450
00:59:09,270 --> 00:59:07,680
are present here and we're storing the

1451
00:59:11,430 --> 00:59:09,280
fluids under these highly reducing

1452
00:59:13,829 --> 00:59:11,440
conditions and then they're in contact

1453
00:59:16,309 --> 00:59:13,839
with a more active hydrologic regime

1454
00:59:18,390 --> 00:59:16,319
which is where we have nitrate sulfate

1455
00:59:20,710 --> 00:59:18,400
bearing fluids that are circulating

1456
00:59:23,349 --> 00:59:20,720
through and some dissolve co2

1457
00:59:25,670 --> 00:59:23,359
these are anoxic so oxygen scrubbed out

1458
00:59:27,510 --> 00:59:25,680
incredibly quickly in these systems the

1459
00:59:28,710 --> 00:59:27,520
temperatures they're only 30 to 40

1460
00:59:30,470 --> 00:59:28,720
degrees c

1461
00:59:33,349 --> 00:59:30,480
and the other component of the rogue

1462
00:59:35,109 --> 00:59:33,359
slide is just that remember again we can

1463
00:59:36,390 --> 00:59:35,119

look very closely at the mineralogy down

1464
00:59:38,710 --> 00:59:36,400
hole and from the cores that we've

1465
00:59:40,549 --> 00:59:38,720
recovered and so we're able to pair

1466
00:59:42,069 --> 00:59:40,559
those states of the system against where

1467
00:59:43,750 --> 00:59:42,079
we see an enormous amount of relic

1468
00:59:46,549 --> 00:59:43,760
olivine that's present in the rocks and

1469
00:59:48,069 --> 00:59:46,559
initial serpentinization to areas where

1470
00:59:50,309 --> 00:59:48,079
it's almost fully hydrated and

1471
00:59:53,589 --> 00:59:50,319
serpentinized but we have a lot of

1472
00:59:56,309 --> 00:59:53,599
ferrous ferric phases the green rusts

1473
00:59:58,549 --> 00:59:56,319
or relic spinels and magnetite formation

1474
01:00:01,270 --> 00:59:58,559
and only in the upper 5 or 10 meters do

1475
01:00:03,109 --> 01:00:01,280
we really see oxidized conditions of

1476
01:00:04,549 --> 01:00:03,119
in the rock

1477
01:00:05,670 --> 01:00:04,559
so then this would be a different area

1478
01:00:07,190 --> 01:00:05,680
where we again see pretty strong

1479
01:00:08,950 --> 01:00:07,200
chemical gradients on the slide that i

1480
01:00:10,710 --> 01:00:08,960
have moved on to now where i'm saying

1481
01:00:13,430 --> 01:00:10,720
there's a lot of reducing power left the

1482
01:00:14,870 --> 01:00:13,440
idea here is simply that

1483
01:00:16,870 --> 01:00:14,880
we can go to some of the holes at the

1484
01:00:19,990 --> 01:00:16,880
most extreme conditions of high ph

1485
01:00:21,910 --> 01:00:20,000
sitting at 11 and a half or so and we

1486
01:00:24,069 --> 01:00:21,920
again land on the lower stability limit

1487
01:00:26,230 --> 01:00:24,079
of water there's not much relic olivine

1488
01:00:28,390 --> 01:00:26,240

here but there's a lot of reducing power

1489
01:00:30,630 --> 01:00:28,400
both from things like awareite that were

1490
01:00:32,390 --> 01:00:30,640
generated under high hydrogen fugacity

1491
01:00:34,630 --> 01:00:32,400
during the water rock reactions at these

1492
01:00:36,470 --> 01:00:34,640
low temperatures and the prevalence of

1493
01:00:38,549 --> 01:00:36,480
these minerals such as brucite it's a

1494
01:00:40,390 --> 01:00:38,559
magnesium iron hydroxide phase it's

1495
01:00:41,990 --> 01:00:40,400
substituting an enormous amount of iron

1496
01:00:44,470 --> 01:00:42,000
into its crystal structure at these low

1497
01:00:46,710 --> 01:00:44,480
temperatures often up to 35 percent of

1498
01:00:48,549 --> 01:00:46,720
the cation component that's in here and

1499
01:00:50,150 --> 01:00:48,559
that iron ii and bruce site is playing a

1500
01:00:53,750 --> 01:00:50,160
big role in the buffering the aqs

1501
01:00:56,870 --> 01:00:55,270
so

1502
01:00:58,150 --> 01:00:56,880
to come back to the sense of not only is

1503
01:00:59,750 --> 01:00:58,160
this a habitable environment with the

1504
01:01:02,069 --> 01:00:59,760
chemical disequilibrium but it is

1505
01:01:03,589 --> 01:01:02,079
inhabited and it's actually a thriving

1506
01:01:06,870 --> 01:01:03,599
biosphere from every measure that we've

1507
01:01:08,230 --> 01:01:06,880
been able to to apply to this so far

1508
01:01:09,990 --> 01:01:08,240
so as we're starting to look into the

1509
01:01:11,990 --> 01:01:10,000
rock course to do life detection for

1510
01:01:13,510 --> 01:01:12,000
example we're thrilled at the

1511
01:01:15,750 --> 01:01:13,520
opportunities when for example we can

1512
01:01:17,910 --> 01:01:15,760
pop out these large cell clusters that

1513
01:01:19,910 --> 01:01:17,920

seem to be distributed into some of the

1514
01:01:21,349 --> 01:01:19,920
parts of the fracture system although

1515
01:01:22,710 --> 01:01:21,359
we're very interested to know exactly

1516
01:01:24,309 --> 01:01:22,720
where those are localized and where

1517
01:01:26,630 --> 01:01:24,319
we'll have the best probability of

1518
01:01:28,470 --> 01:01:26,640
finding them

1519
01:01:30,470 --> 01:01:28,480
in general we've been able to

1520
01:01:32,630 --> 01:01:30,480
interrogate both the fluid and the rock

1521
01:01:35,510 --> 01:01:32,640
system to try and determine cell

1522
01:01:37,190 --> 01:01:35,520
abundances and it remains quite high

1523
01:01:38,950 --> 01:01:37,200
through most of the system so if you

1524
01:01:40,230 --> 01:01:38,960
look at it from a fluid perspective from

1525
01:01:42,789 --> 01:01:40,240
some of the cell counting work that

1526
01:01:45,030 --> 01:01:42,799
libby phones did we're almost always at

1527
01:01:47,109 --> 01:01:45,040
sea water type cell abundances of ten to

1528
01:01:48,309 --> 01:01:47,119
the five up to ten to the six cells per

1529
01:01:50,390 --> 01:01:48,319
mil

1530
01:01:52,470 --> 01:01:50,400
when we move into the rock cores we're

1531
01:01:54,789 --> 01:01:52,480
often homogenizing or taking a sample

1532
01:01:56,870 --> 01:01:54,799
from a large volume of rock in which

1533
01:01:59,990 --> 01:01:56,880
the cell densities can range from 10 to

1534
01:02:03,029 --> 01:02:00,000
the 2 to 10 to the seven cells per gram

1535
01:02:05,109 --> 01:02:03,039
um and and but again these are like

1536
01:02:07,430 --> 01:02:05,119
robust numbers in terms of the biomass

1537
01:02:10,789 --> 01:02:07,440
that's being harbored within the rock

1538
01:02:14,789 --> 01:02:12,710

so our goal right now is how to improve

1539
01:02:16,470 --> 01:02:14,799
our strategies to detect

1540
01:02:18,630 --> 01:02:16,480
evidence of both preserved life and

1541
01:02:19,829 --> 01:02:18,640
current life activity in these rocks we

1542
01:02:21,750 --> 01:02:19,839
want to be able to answer these

1543
01:02:23,910 --> 01:02:21,760
questions if you pick up a serpent night

1544
01:02:25,270 --> 01:02:23,920
that's undergone extensive hydration

1545
01:02:28,390 --> 01:02:25,280
even at low temperatures how do you

1546
01:02:30,950 --> 01:02:28,400
prove that it was alive or is right now

1547
01:02:32,230 --> 01:02:30,960
in the shallowest samples that have been

1548
01:02:33,430 --> 01:02:32,240
recovered from the amman drilling

1549
01:02:35,430 --> 01:02:33,440
project where there's extensive

1550
01:02:37,109 --> 01:02:35,440
carbonation there's been work that's

1551
01:02:38,630 --> 01:02:37,119
ongoing by john zillumis and his

1552
01:02:40,870 --> 01:02:38,640
collaborators to try and look in the

1553
01:02:42,950 --> 01:02:40,880
carbonate phases at the preservation of

1554
01:02:44,390 --> 01:02:42,960
filaments iron oxide structures and

1555
01:02:45,829 --> 01:02:44,400
organic carbon that are preserved in

1556
01:02:48,630 --> 01:02:45,839
there and to interrogate them for their

1557
01:02:50,309 --> 01:02:48,640
potential as biosignatures

1558
01:02:52,069 --> 01:02:50,319
in my lab one of the things that we're

1559
01:02:54,870 --> 01:02:52,079
focusing on more is as we move into this

1560
01:02:56,710 --> 01:02:54,880
anoxic anaerobic subsurface biosphere

1561
01:02:58,710 --> 01:02:56,720
system the massive volume that really

1562
01:03:00,549 --> 01:02:58,720
dominates this environment

1563
01:03:02,789 --> 01:03:00,559

how do we start to detect where there

1564
01:03:04,230 --> 01:03:02,799
are active cells

1565
01:03:06,069 --> 01:03:04,240
one of the approaches that we commonly

1566
01:03:07,430 --> 01:03:06,079
use is to use hyperspectral raman

1567
01:03:09,670 --> 01:03:07,440
imaging we're often doing it at the

1568
01:03:11,750 --> 01:03:09,680
microscale and from it we can pull out

1569
01:03:13,829 --> 01:03:11,760
exquisite textures of the complex

1570
01:03:15,670 --> 01:03:13,839
alteration history of these rocks the

1571
01:03:18,069 --> 01:03:15,680
different generations of serpentine that

1572
01:03:19,990 --> 01:03:18,079
are there and then within nested in that

1573
01:03:21,589 --> 01:03:20,000
framework to start to look for then

1574
01:03:23,430 --> 01:03:21,599
things like lipids that are preserved

1575
01:03:25,589 --> 01:03:23,440
from cells or active cells that are

1576
01:03:27,190 --> 01:03:25,599
there so i just point you now to look at

1577
01:03:29,270 --> 01:03:27,200
some talks there this afternoon from

1578
01:03:30,630 --> 01:03:29,280
both trisha kashyap and tristan caro who

1579
01:03:32,390 --> 01:03:30,640
are going to talk in the life detection

1580
01:03:37,109 --> 01:03:32,400
and deep biospheres about some of the

1581
01:03:40,710 --> 01:03:38,870
what we have more data about is at the

1582
01:03:42,630 --> 01:03:40,720
bulk scale and by bulk scale i mean

1583
01:03:44,470 --> 01:03:42,640
taking a chunk of raw core

1584
01:03:46,549 --> 01:03:44,480
and being able to then put it into a

1585
01:03:48,309 --> 01:03:46,559
series of assays or to take biomass

1586
01:03:49,990 --> 01:03:48,319
pumped from fluids and use them in a

1587
01:03:51,109 --> 01:03:50,000
series of assays to measure microbial

1588
01:03:53,589 --> 01:03:51,119

activity

1589
01:03:55,190 --> 01:03:53,599
and one thing that we have feel very

1590
01:03:57,510 --> 01:03:55,200
confident in now is that biological

1591
01:03:59,910 --> 01:03:57,520
methanogenesis is prevalent

1592
01:04:01,750 --> 01:03:59,920
and that might not seem like a surprise

1593
01:04:03,829 --> 01:04:01,760
but when you do look at the geochemical

1594
01:04:05,990 --> 01:04:03,839
state of these fluids at ph 11 and the

1595
01:04:07,910 --> 01:04:06,000
low carbon availability there are many

1596
01:04:09,990 --> 01:04:07,920
many conundrums about the physiological

1597
01:04:11,430 --> 01:04:10,000
adaptations to allow methanogenesis to

1598
01:04:13,829 --> 01:04:11,440
proceed

1599
01:04:16,309 --> 01:04:13,839
bulk chemical isotopic measures like

1600
01:04:18,630 --> 01:04:16,319
delta 13c of methane also indicates that

1601
01:04:19,829 --> 01:04:18,640
maybe it's potentially bio abiotic

1602
01:04:21,510 --> 01:04:19,839
source

1603
01:04:23,510 --> 01:04:21,520
however a series of different works that

1604
01:04:24,870 --> 01:04:23,520
have come out in the last two years

1605
01:04:26,950 --> 01:04:24,880
come back again and again and say

1606
01:04:28,390 --> 01:04:26,960
there's evidence for biological activity

1607
01:04:30,549 --> 01:04:28,400
the producing methane under these

1608
01:04:32,230 --> 01:04:30,559
conditions some of them are from dan no

1609
01:04:33,750 --> 01:04:32,240
taft he's published a series of papers

1610
01:04:35,510 --> 01:04:33,760
with isotopolog

1611
01:04:37,670 --> 01:04:35,520
geochemistry of methane that shows a

1612
01:04:40,309 --> 01:04:37,680
kinetic disequilibrium preserved in the

1613
01:04:42,309 --> 01:04:40,319

methane that's abundant in these systems

1614
01:04:44,470 --> 01:04:42,319
other work comes from emily krauss she

1615
01:04:46,069 --> 01:04:44,480
was looking quite a bit at both just the

1616
01:04:47,670 --> 01:04:46,079
abundance of methanogens across

1617
01:04:50,470 --> 01:04:47,680
different geochemical parts of the

1618
01:04:52,390 --> 01:04:50,480
system they often can be up to 20 25

1619
01:04:54,950 --> 01:04:52,400
percent of the total population mostly

1620
01:04:56,710 --> 01:04:54,960
methanobacterium species but at times

1621
01:04:58,789 --> 01:04:56,720
when you quantify the transcripts from

1622
01:05:01,510 --> 01:04:58,799
those same fluids it can be more than 65

1623
01:05:03,589 --> 01:05:01,520
percent of those total abundance

1624
01:05:05,109 --> 01:05:03,599
and then libby phones has done

1625
01:05:07,109 --> 01:05:05,119
quite a

1626
01:05:09,349 --> 01:05:07,119
beautiful body of work in her thesis

1627
01:05:11,349 --> 01:05:09,359
that first was looking at quantifying

1628
01:05:13,430 --> 01:05:11,359
the rates of conversion of 14 labeled

1629
01:05:15,430 --> 01:05:13,440
bicarbonate into methane from different

1630
01:05:18,390 --> 01:05:15,440
geochemical states of the system and

1631
01:05:20,150 --> 01:05:18,400
then trying to look at some of the uh

1632
01:05:21,910 --> 01:05:20,160
diversification of the methanogens in

1633
01:05:24,630 --> 01:05:21,920
these systems and their adaptations to

1634
01:05:26,630 --> 01:05:24,640
growing at hyper alkaline ph and import

1635
01:05:28,150 --> 01:05:26,640
in particular the role of formate as was

1636
01:05:30,069 --> 01:05:28,160
just mentioned in the previous talk and

1637
01:05:31,750 --> 01:05:30,079
by billy and susan lang and others comes

1638
01:05:33,510 --> 01:05:31,760

back again and again trying to

1639
01:05:36,150 --> 01:05:33,520
understand the role format's playing as

1640
01:05:37,750 --> 01:05:36,160
an intermediate in these systems

1641
01:05:39,270 --> 01:05:37,760
so in libby's

1642
01:05:40,789 --> 01:05:39,280
work she first started working in the

1643
01:05:42,950 --> 01:05:40,799
fluids looking at rates of formate

1644
01:05:44,870 --> 01:05:42,960
conversion to methane and the pathways

1645
01:05:46,470 --> 01:05:44,880
at which it was being used or she also

1646
01:05:48,470 --> 01:05:46,480
moved into starting to look at the rock

1647
01:05:50,549 --> 01:05:48,480
cores themselves and one of the

1648
01:05:53,029 --> 01:05:50,559
surprises for us was that when we could

1649
01:05:54,710 --> 01:05:53,039
get a measure of uh formate both

1650
01:05:57,029 --> 01:05:54,720
conversion to methane or formate

1651
01:05:58,470 --> 01:05:57,039
oxidation in the cores it's sometimes

1652
01:06:00,069 --> 01:05:58,480
several orders of magnitude higher than

1653
01:06:01,750 --> 01:06:00,079
what we saw in the fluids

1654
01:06:03,270 --> 01:06:01,760
and i think we've had a bias so far that

1655
01:06:04,950 --> 01:06:03,280
the fluid system was where a lot of the

1656
01:06:07,349 --> 01:06:04,960
dynamics and activity were occurring

1657
01:06:09,270 --> 01:06:07,359
biologically but again it brings us back

1658
01:06:10,950 --> 01:06:09,280
to wanting to understand where and how

1659
01:06:12,789 --> 01:06:10,960
in the in the rock cores themselves

1660
01:06:15,670 --> 01:06:12,799
these microbial communities are being so

1661
01:06:19,190 --> 01:06:17,430
so pivoting a little bit we have also

1662
01:06:20,870 --> 01:06:19,200
been focusing on processes such as

1663
01:06:23,029 --> 01:06:20,880

sulfate reduction

1664
01:06:24,950 --> 01:06:23,039
this is a terrestrial system however

1665
01:06:27,510 --> 01:06:24,960
sulfate's abundant through prior water

1666
01:06:29,029 --> 01:06:27,520
rock reactions on the seafloor

1667
01:06:31,109 --> 01:06:29,039
and other sources of sulfate that have

1668
01:06:33,190 --> 01:06:31,119
been stored within these rocks so we can

1669
01:06:35,990 --> 01:06:33,200
often have up to millimolar constant up

1670
01:06:37,430 --> 01:06:36,000
to millimolar concentration of sulfate

1671
01:06:40,150 --> 01:06:37,440
and clemens glombits are working in

1672
01:06:42,390 --> 01:06:40,160
torrey holders lab applied techniques

1673
01:06:44,630 --> 01:06:42,400
often used in deep sea sediments to use

1674
01:06:47,029 --> 01:06:44,640
35 labeled sulfate and try to measure

1675
01:06:48,789 --> 01:06:47,039
rates of biological sulfate reduction

1676
01:06:51,349 --> 01:06:48,799
in the fluid system and then later

1677
01:06:53,430 --> 01:06:51,359
within the rock cores themselves

1678
01:06:54,950 --> 01:06:53,440
the rates are exceedingly slow they're

1679
01:06:56,390 --> 01:06:54,960
hard to measure they're just above the

1680
01:06:57,910 --> 01:06:56,400
limits of detection and some of the

1681
01:07:00,069 --> 01:06:57,920
slowest rates that have been measured on

1682
01:07:01,510 --> 01:07:00,079
earth but they are pervasive again and

1683
01:07:02,950 --> 01:07:01,520
have been able to be measured in both

1684
01:07:04,789 --> 01:07:02,960
systems

1685
01:07:06,150 --> 01:07:04,799
and so we've become increasingly

1686
01:07:07,910 --> 01:07:06,160
interested in the

1687
01:07:09,670 --> 01:07:07,920
importance of

1688
01:07:13,190 --> 01:07:09,680

this slow sulfate reduction in the

1689
01:07:15,990 --> 01:07:13,200
overall geochemical dynamics within um

1690
01:07:20,470 --> 01:07:18,549
specifically for example during drilling

1691
01:07:22,390 --> 01:07:20,480
we started to notice that often we would

1692
01:07:24,390 --> 01:07:22,400
bring up core intervals that were

1693
01:07:26,789 --> 01:07:24,400
degassing you can see sort of a bubbling

1694
01:07:28,309 --> 01:07:26,799
wet core here on the left and when we

1695
01:07:30,470 --> 01:07:28,319
look at these optically through a thin

1696
01:07:32,549 --> 01:07:30,480
section they're optically darkened

1697
01:07:34,470 --> 01:07:32,559
they're becoming more opaque

1698
01:07:36,069 --> 01:07:34,480
and the total sulfur content in these

1699
01:07:39,190 --> 01:07:36,079
serpent nights is not high it's the

1700
01:07:40,870 --> 01:07:39,200
maximum of them up to 0.68 percent

1701
01:07:42,549 --> 01:07:40,880
but our interest is in

1702
01:07:44,069 --> 01:07:42,559
when and how are the reactions with

1703
01:07:46,470 --> 01:07:44,079
sulfur occurring

1704
01:07:48,309 --> 01:07:46,480
and to have hydrogen sulfide produced in

1705
01:07:50,230 --> 01:07:48,319
these fluids which also can be detected

1706
01:07:51,430 --> 01:07:50,240
is is intriguing because at these

1707
01:07:53,109 --> 01:07:51,440
temperatures we're not expecting

1708
01:07:55,190 --> 01:07:53,119
thermochemical sulfate reduction to

1709
01:07:57,510 --> 01:07:55,200
occur so again we're just deferring it

1710
01:08:00,549 --> 01:07:57,520
to be a biological process as also shown

1711
01:08:04,789 --> 01:08:02,470
we're working with bethany ellman and

1712
01:08:05,910 --> 01:08:04,799
rebecca greenberger in another related

1713
01:08:07,990 --> 01:08:05,920

project

1714
01:08:09,910 --> 01:08:08,000
where rebecca was able to scan the

1715
01:08:11,829 --> 01:08:09,920
entire one kilometer of core obtained

1716
01:08:13,589 --> 01:08:11,839
from the subsurface to look at its

1717
01:08:15,109 --> 01:08:13,599
spectral characteristics and we can from

1718
01:08:16,229 --> 01:08:15,119
that define different styles of

1719
01:08:19,110 --> 01:08:16,239
surretinization and different

1720
01:08:21,669 --> 01:08:19,120
geochemical regimes in the rock core

1721
01:08:23,990 --> 01:08:21,679
and often she's looking at the iron 2 or

1722
01:08:25,590 --> 01:08:24,000
iron 2 3 transitions in the serpentine

1723
01:08:27,349 --> 01:08:25,600
in terms of the ways that she's imaging

1724
01:08:29,269 --> 01:08:27,359
it but the second you get to these

1725
01:08:30,789 --> 01:08:29,279
partly sulfurized cores the optical

1726
01:08:32,709 --> 01:08:30,799
darkening and the decrease in the

1727
01:08:35,990 --> 01:08:32,719
reflectance really changes the signal

1728
01:08:39,749 --> 01:08:38,070
so we're zoning in on those areas within

1729
01:08:41,030 --> 01:08:39,759
our cores and starting to look at them

1730
01:08:43,349 --> 01:08:41,040
optically and again back with things

1731
01:08:45,269 --> 01:08:43,359
like ramen or an x-ray spectroscopy

1732
01:08:47,590 --> 01:08:45,279
trying to characterize the sulfurization

1733
01:08:49,349 --> 01:08:47,600
process itself and in this particular

1734
01:08:50,870 --> 01:08:49,359
case with this kind of mapping we would

1735
01:08:52,950 --> 01:08:50,880
be able to start to see sulfide

1736
01:08:55,749 --> 01:08:52,960
replacement of olivine mesh cores the

1737
01:08:58,470 --> 01:08:55,759
brucite that replaced the olivine is now

1738
01:09:00,070 --> 01:08:58,480

being itself replaced by sulfide

1739
01:09:01,590 --> 01:09:00,080
and we can see reaction rims that are

1740
01:09:03,269 --> 01:09:01,600
forming within them

1741
01:09:05,189 --> 01:09:03,279
and this is giving us the mineralogical

1742
01:09:06,870 --> 01:09:05,199
context to again want to come back and

1743
01:09:08,709 --> 01:09:06,880
ask the question where are microbial

1744
01:09:10,709 --> 01:09:08,719
cells distributed within this and where

1745
01:09:15,990 --> 01:09:10,719
are they active and what's the potential

1746
01:09:19,669 --> 01:09:17,510
if we step back out of the micro scale

1747
01:09:21,349 --> 01:09:19,679
back to just the bulk rock scale an

1748
01:09:23,990 --> 01:09:21,359
example of this too would be work by

1749
01:09:25,910 --> 01:09:24,000
katie remfort in her phd thesis

1750
01:09:27,510 --> 01:09:25,920
she came and took several intervals of

1751
01:09:29,430 --> 01:09:27,520
subsurface course trying to see if she

1752
01:09:31,030 --> 01:09:29,440
could successfully extract intact polar

1753
01:09:33,349 --> 01:09:31,040
lipids from the active microbial

1754
01:09:35,430 --> 01:09:33,359
community she's also done that from

1755
01:09:37,110 --> 01:09:35,440
pumping the fluids that circulate within

1756
01:09:38,149 --> 01:09:37,120
the system and collecting biomass there

1757
01:09:40,229 --> 01:09:38,159
too

1758
01:09:41,990 --> 01:09:40,239
she's a beautifully complex story i'm

1759
01:09:43,990 --> 01:09:42,000
just going to take one component of that

1760
01:09:45,990 --> 01:09:44,000
to say one of the most striking findings

1761
01:09:47,749 --> 01:09:46,000
from our work is that despite us knowing

1762
01:09:49,510 --> 01:09:47,759
that we have quite a complex microbial

1763
01:09:51,110 --> 01:09:49,520

community structure

1764
01:09:53,110 --> 01:09:51,120
what we see again and again in the

1765
01:09:54,310 --> 01:09:53,120
intact polar lipids that are

1766
01:09:55,830 --> 01:09:54,320
able to be

1767
01:09:57,669 --> 01:09:55,840
extracted and characterized from the

1768
01:09:59,750 --> 01:09:57,679
system is this dominance of these

1769
01:10:01,510 --> 01:09:59,760
glycodiete or lipids

1770
01:10:02,630 --> 01:10:01,520
and part of those are archaeol that

1771
01:10:04,950 --> 01:10:02,640
we're attributing back to

1772
01:10:07,149 --> 01:10:04,960
methanobacterium that's so dominant in

1773
01:10:10,149 --> 01:10:07,159
our system as well as these

1774
01:10:11,750 --> 01:10:10,159
non-isoprenoidal dietherglycerol lipids

1775
01:10:13,669 --> 01:10:11,760
that we attribute to sulfate-reducing

1776
01:10:15,750 --> 01:10:13,679
bacteria which there are many present

1777
01:10:17,590 --> 01:10:15,760
but thermodesulfa vibrio is one of them

1778
01:10:19,669 --> 01:10:17,600
that we have in culture and are working

1779
01:10:21,910 --> 01:10:19,679
with to characterize the correspondence

1780
01:10:24,070 --> 01:10:21,920
in those lipids and they often together

1781
01:10:26,229 --> 01:10:24,080
just these two make up more than 90 95

1782
01:10:28,870 --> 01:10:26,239
percent of the total ipls that can be

1783
01:10:33,030 --> 01:10:30,550
so thanks for your patience through that

1784
01:10:34,390 --> 01:10:33,040
little intermission and um in general

1785
01:10:36,310 --> 01:10:34,400
the part i didn't get to show you but

1786
01:10:38,790 --> 01:10:36,320
i'm still really excited to leave a

1787
01:10:40,310 --> 01:10:38,800
visual imprint of is the really strong

1788
01:10:41,990 --> 01:10:40,320

chemical gradients existing in the

1789
01:10:44,390 --> 01:10:42,000
shallow subsurface even of these low

1790
01:10:46,310 --> 01:10:44,400
temperature cool systems and strong

1791
01:10:48,310 --> 01:10:46,320
reductance persist which allow these to

1792
01:10:49,910 --> 01:10:48,320
be maintained over long time scales to

1793
01:10:51,430 --> 01:10:49,920
have this disequilibrium present and

1794
01:10:52,950 --> 01:10:51,440
harnessed

1795
01:10:54,630 --> 01:10:52,960
we're seeing a very

1796
01:10:56,709 --> 01:10:54,640
abundant biosphere in my opinion at

1797
01:10:58,790 --> 01:10:56,719
these kind of high cell at these cell

1798
01:11:01,030 --> 01:10:58,800
densities in both fluids and in rocks

1799
01:11:02,950 --> 01:11:01,040
greater than 10 to the five

1800
01:11:05,830 --> 01:11:02,960
and when we take whole rock cores or

1801
01:11:07,590 --> 01:11:05,840
take um fluid biomass we can definitely

1802
01:11:10,470 --> 01:11:07,600
measure activity turning over things

1803
01:11:13,189 --> 01:11:10,480
like 14c bicarbonate formate

1804
01:11:14,709 --> 01:11:13,199
sulfate um what we're really interested

1805
01:11:16,470 --> 01:11:14,719
in are what are the real adaptations

1806
01:11:18,390 --> 01:11:16,480
that are allowing the microbial like to

1807
01:11:19,830 --> 01:11:18,400
be active in the system and again dan

1808
01:11:23,189 --> 01:11:19,840
will talk a little bit about that in

1809
01:11:24,709 --> 01:11:23,199
terms of acetogenesis in just a moment

1810
01:11:26,470 --> 01:11:24,719
but in this question of how do we come

1811
01:11:28,550 --> 01:11:26,480
recognize that the system's alive and

1812
01:11:30,709 --> 01:11:28,560
how do we know what to target for in

1813
01:11:33,110 --> 01:11:30,719

terms of analysis for biosignatures or

1814
01:11:35,030 --> 01:11:33,120
showing life activity at that cellular

1815
01:11:37,030 --> 01:11:35,040
scale we're very intrigued by the

1816
01:11:39,350 --> 01:11:37,040
sulfurization of these causes occurring

1817
01:11:41,669 --> 01:11:39,360
not only to be potentially a signature

1818
01:11:43,430 --> 01:11:41,679
that this is an active system but also

1819
01:11:45,830 --> 01:11:43,440
because it may well be playing a role in

1820
01:11:48,070 --> 01:11:45,840
preserving some of the lipids that are

1821
01:11:49,669 --> 01:11:48,080
in the biomass that's present

1822
01:11:51,270 --> 01:11:49,679
and with that i'll move to this

1823
01:11:53,030 --> 01:11:51,280
afternoon session and just encourage you

1824
01:11:55,189 --> 01:11:53,040
to come and hear more about efforts to

1825
01:12:07,990 --> 01:11:55,199
detect activity in specific microbe

1826
01:12:12,149 --> 01:12:10,390
have time for one question and we

1827
01:12:14,310 --> 01:12:12,159
encourage others to

1828
01:12:26,709 --> 01:12:14,320
speak to alexis after the session as

1829
01:12:31,030 --> 01:12:29,270
hi alexis wonderful presentation i was

1830
01:12:33,110 --> 01:12:31,040
wondering if you have a sample where

1831
01:12:35,110 --> 01:12:33,120
you're both measuring the methane

1832
01:12:37,510 --> 01:12:35,120
production rate and

1833
01:12:39,030 --> 01:12:37,520
the cell densities i'm trying to tune a

1834
01:12:41,510 --> 01:12:39,040
biomass model

1835
01:12:43,669 --> 01:12:41,520
yeah if you look to libby phone's work

1836
01:12:45,910 --> 01:12:43,679
um she did do that so she's got the cell

1837
01:12:48,550 --> 01:12:45,920
numbers that correlate also with the

1838
01:12:52,070 --> 01:12:48,560

activity now she's the system stimulated

1839
01:12:54,630 --> 01:12:52,080
because in that case they're adding

1840
01:12:56,630 --> 01:12:54,640
14c bicarbonate or formate

1841
01:12:58,470 --> 01:12:56,640
often at a millimolar concentration and

1842
01:12:59,750 --> 01:12:58,480
the ambient concentrations in the system

1843
01:13:02,149 --> 01:12:59,760
tend to be

1844
01:13:03,270 --> 01:13:02,159
in micromolar concentration but that's

1845
01:13:04,950 --> 01:13:03,280
probably where you could find the best

1846
01:13:06,709 --> 01:13:04,960
data of both the geochemical state and

1847
01:13:08,709 --> 01:13:06,719
the cell density

1848
01:13:10,550 --> 01:13:08,719
awesome things yeah

1849
01:13:12,790 --> 01:13:10,560
thank you alexis thank you

1850
01:13:28,470 --> 01:13:12,800
our next speaker is daniel coleman from

1851
01:13:38,950 --> 01:13:35,590
right

1852
01:13:39,910 --> 01:13:38,960
chalk talk so that's a good start

1853
01:13:41,110 --> 01:13:39,920
um

1854
01:13:42,390 --> 01:13:41,120
thank you to the convenience for the

1855
01:13:43,430 --> 01:13:42,400
opportunity to talk about some of my

1856
01:13:45,030 --> 01:13:43,440
research

1857
01:13:46,390 --> 01:13:45,040
that was a great introduction to it and

1858
01:13:48,149 --> 01:13:46,400
alexis's talk

1859
01:13:49,669 --> 01:13:48,159
my name is dan coleman i'm an assistant

1860
01:13:51,990 --> 01:13:49,679
research professor at montana state

1861
01:13:53,430 --> 01:13:52,000
university and eric boyd's lab um so

1862
01:13:55,750 --> 01:13:53,440
what i'm going to talk to you about

1863
01:13:57,110 --> 01:13:55,760

today is kind of extending on from the

1864
01:13:58,709 --> 01:13:57,120
work that alexis was just talking about

1865
01:14:00,390 --> 01:13:58,719
in the smell ophelia

1866
01:14:02,149 --> 01:14:00,400
and looking at adaptations of peter

1867
01:14:06,149 --> 01:14:02,159
acetogens that are dominant in some of

1868
01:14:09,830 --> 01:14:08,149
so as many of us in the room are pretty

1869
01:14:11,189 --> 01:14:09,840
well acquainted with this idea and a lot

1870
01:14:12,390 --> 01:14:11,199
of the talks in the session have really

1871
01:14:14,310 --> 01:14:12,400
elegantly

1872
01:14:16,390 --> 01:14:14,320
pointed this out the serpentinite hosted

1873
01:14:17,910 --> 01:14:16,400
environments are really ideal analogs

1874
01:14:19,350 --> 01:14:17,920
for trying to understand the habitats

1875
01:14:20,310 --> 01:14:19,360
that supported some of the earliest life

1876
01:14:21,990 --> 01:14:20,320
on earth

1877
01:14:23,910 --> 01:14:22,000
as well as the potential for life on

1878
01:14:25,669 --> 01:14:23,920
other planetary systems

1879
01:14:26,870 --> 01:14:25,679
one of the most important attributes of

1880
01:14:28,310 --> 01:14:26,880
these systems are the water rock

1881
01:14:30,870 --> 01:14:28,320
interactions that are in current

1882
01:14:31,990 --> 01:14:30,880
occurring in these serpentinite systems

1883
01:14:33,910 --> 01:14:32,000
and especially the production of

1884
01:14:35,669 --> 01:14:33,920
abundant amounts of hydrogen right it's

1885
01:14:36,950 --> 01:14:35,679
these water rock interactions that

1886
01:14:38,870 --> 01:14:36,960
produce these substrates that can

1887
01:14:40,630 --> 01:14:38,880
support chemosynthetic life through

1888
01:14:42,390 --> 01:14:40,640

things like hydrogen and one carbon

1889
01:14:43,910 --> 01:14:42,400
compounds like formate and so when i

1890
01:14:45,510 --> 01:14:43,920
talk about chemosynthetic life i'm

1891
01:14:47,750 --> 01:14:45,520
talking about organisms that use

1892
01:14:49,830 --> 01:14:47,760
chemical energy as their primary uh

1893
01:14:51,110 --> 01:14:49,840
source to produce biomass

1894
01:14:53,270 --> 01:14:51,120
and so as this

1895
01:14:54,390 --> 01:14:53,280
uh kind of really brief equation is

1896
01:14:55,830 --> 01:14:54,400
showing here it's the hydration of

1897
01:14:57,189 --> 01:14:55,840
ultramafic minerals in the production of

1898
01:14:59,350 --> 01:14:57,199
hydrogen that's really important in this

1899
01:15:01,110 --> 01:14:59,360
process

1900
01:15:02,470 --> 01:15:01,120
and so among the types of organisms that

1901
01:15:04,470 --> 01:15:02,480
have really been the focus for trying to

1902
01:15:06,550 --> 01:15:04,480
understand who these early

1903
01:15:08,870 --> 01:15:06,560
potential analogs of life on earth might

1904
01:15:10,470 --> 01:15:08,880
be acetogens and methanogens have been

1905
01:15:11,830 --> 01:15:10,480
at the forefront of these discussions

1906
01:15:13,750 --> 01:15:11,840
and there's ketogenic bacteria in

1907
01:15:15,030 --> 01:15:13,760
methanogenic archaea

1908
01:15:17,030 --> 01:15:15,040
and that's primarily because these

1909
01:15:19,110 --> 01:15:17,040
organisms use these simple content

1910
01:15:21,590 --> 01:15:19,120
compounds hydrogen and dissolved in

1911
01:15:23,189 --> 01:15:21,600
organic carbon to produce biomass

1912
01:15:24,310 --> 01:15:23,199
through simple enzymatic pathways which

1913
01:15:26,790 --> 01:15:24,320

i'll touch on a little bit throughout

1914
01:15:30,310 --> 01:15:28,630
so what i would argue is we're trying to

1915
01:15:31,750 --> 01:15:30,320
we're starting to learn quite a bit more

1916
01:15:33,350 --> 01:15:31,760
about these types of organisms that are

1917
01:15:34,630 --> 01:15:33,360
present in these environments but we

1918
01:15:36,070 --> 01:15:34,640
still know very little about their

1919
01:15:37,110 --> 01:15:36,080
adaptations and how they're actually

1920
01:15:38,790 --> 01:15:37,120
able to

1921
01:15:41,110 --> 01:15:38,800
to thrive in these particularly harsh

1922
01:15:43,270 --> 01:15:41,120
systems

1923
01:15:44,709 --> 01:15:43,280
so the work i'm going to discuss today

1924
01:15:46,070 --> 01:15:44,719
as part of my research extends out from

1925
01:15:46,870 --> 01:15:46,080
what alexis was talking about in the

1926
01:15:49,270 --> 01:15:46,880
same

1927
01:15:50,390 --> 01:15:49,280
opioid noman it's really an exemplary

1928
01:15:53,030 --> 01:15:50,400
system for trying to understand

1929
01:15:54,390 --> 01:15:53,040
microbial adaptations to

1930
01:15:55,830 --> 01:15:54,400
serpentinite

1931
01:15:57,669 --> 01:15:55,840
systems and the water rock interactions

1932
01:15:58,790 --> 01:15:57,679
that occur there for a couple reasons

1933
01:15:59,830 --> 01:15:58,800
one it's

1934
01:16:01,750 --> 01:15:59,840
really accessible it's one of the

1935
01:16:03,110 --> 01:16:01,760
largest near-surface ophiolite systems

1936
01:16:04,550 --> 01:16:03,120
on earth

1937
01:16:05,990 --> 01:16:04,560
two there are wells that had been

1938
01:16:08,310 --> 01:16:06,000

previously drilled there that tap into

1939
01:16:09,590 --> 01:16:08,320
deep subsurface waters

1940
01:16:11,430 --> 01:16:09,600
and the third

1941
01:16:13,030 --> 01:16:11,440
thing that i'm going to touch on kind of

1942
01:16:14,550 --> 01:16:13,040
throughout the presentation is that

1943
01:16:16,550 --> 01:16:14,560
there's a gradient in water types that

1944
01:16:18,630 --> 01:16:16,560
are present in the subsurface of the

1945
01:16:19,910 --> 01:16:18,640
same ophelite so there are waters that

1946
01:16:22,229 --> 01:16:19,920
are essentially meteoric these are

1947
01:16:24,070 --> 01:16:22,239
slightly alkaline types of waters of ph

1948
01:16:25,590 --> 01:16:24,080
maybe eight to nine or so

1949
01:16:27,110 --> 01:16:25,600
and as more extensive water rock

1950
01:16:29,750 --> 01:16:27,120
interactions occur in the subsurface

1951
01:16:31,910 --> 01:16:29,760
these waters become progressively more

1952
01:16:34,149 --> 01:16:31,920
alkaline up to hyperalkaline

1953
01:16:36,950 --> 01:16:34,159
types of subsurface fluids and so this

1954
01:16:38,310 --> 01:16:36,960
gradient really then allows us as

1955
01:16:40,310 --> 01:16:38,320
microbiologists to understand the

1956
01:16:43,350 --> 01:16:40,320
adaptations of organisms to this

1957
01:16:44,470 --> 01:16:43,360
spectrum of conditions

1958
01:16:46,950 --> 01:16:44,480
and one thing to keep in mind that i'll

1959
01:16:48,390 --> 01:16:46,960
touch on throughout the talk is that ph

1960
01:16:51,430 --> 01:16:48,400
can serve as a sort of proxy for

1961
01:16:53,189 --> 01:16:51,440
serpentization reaction progress so as

1962
01:16:55,590 --> 01:16:53,199
more serpentization influence more water

1963
01:16:57,189 --> 01:16:55,600

rock interaction occurs uh waters become

1964
01:16:59,430 --> 01:16:57,199
more progressively alkaline as i

1965
01:17:01,110 --> 01:16:59,440
mentioned

1966
01:17:03,669 --> 01:17:01,120
so my work that i'm going to focus on

1967
01:17:05,030 --> 01:17:03,679
today is looking at these unique

1968
01:17:05,910 --> 01:17:05,040
intriguing kind of organisms that we

1969
01:17:08,550 --> 01:17:05,920
found that were dominant in these

1970
01:17:10,310 --> 01:17:08,560
subsurface fluid fluids that belong to

1971
01:17:12,070 --> 01:17:10,320
an uncultured candidate division called

1972
01:17:14,550 --> 01:17:12,080
the acetothermia

1973
01:17:16,470 --> 01:17:14,560
previous work by katie remfer in

1974
01:17:17,830 --> 01:17:16,480
alexis's lab show that these organisms

1975
01:17:20,070 --> 01:17:17,840
were particularly dominant some of the

1976
01:17:24,550 --> 01:17:20,080
most hyper alkaline fluids in the smell

1977
01:17:26,550 --> 01:17:24,560
ophelia using 16s rna gene-based studies

1978
01:17:28,470 --> 01:17:26,560
and so what i wanted to do extending on

1979
01:17:30,390 --> 01:17:28,480
from these initial finds is use a

1980
01:17:32,229 --> 01:17:30,400
genomic approach try to understand

1981
01:17:34,550 --> 01:17:32,239
what the adaptations of these organisms

1982
01:17:36,229 --> 01:17:34,560
are using recovered genomes and that's

1983
01:17:38,470 --> 01:17:36,239
what i did so i used a genome-resolved

1984
01:17:40,550 --> 01:17:38,480
metagenomic approach to recover seven

1985
01:17:42,790 --> 01:17:40,560
different genomes from wells and the

1986
01:17:44,630 --> 01:17:42,800
similar feeling from different years and

1987
01:17:45,990 --> 01:17:44,640
from different wells

1988
01:17:47,669 --> 01:17:46,000

so what's shown here on the right hand

1989
01:17:48,950 --> 01:17:47,679
side is just a phylogenetic analysis

1990
01:17:51,110 --> 01:17:48,960
showing that there's two different types

1991
01:17:52,870 --> 01:17:51,120
of these acethermia that are present in

1992
01:17:54,229 --> 01:17:52,880
these subsurface fluids there's type one

1993
01:17:55,350 --> 01:17:54,239
which i'll show in orange for the rest

1994
01:17:56,790 --> 01:17:55,360
of the talk

1995
01:17:58,149 --> 01:17:56,800
and there's type two which i'll show in

1996
01:18:01,510 --> 01:17:58,159
blue for the rest of the talk the type

1997
01:18:03,030 --> 01:18:01,520
one or more related to subsurface

1998
01:18:04,709 --> 01:18:03,040
type organisms that have been found in

1999
01:18:05,750 --> 01:18:04,719
hot springs other surface systems around

2000
01:18:07,430 --> 01:18:05,760
the globe

2001
01:18:08,550 --> 01:18:07,440
whereas the type two are really only

2002
01:18:10,149 --> 01:18:08,560
related to

2003
01:18:11,910 --> 01:18:10,159
one other

2004
01:18:13,430 --> 01:18:11,920
population that was observed in the lost

2005
01:18:15,669 --> 01:18:13,440
city hydrothermal system which as

2006
01:18:16,790 --> 01:18:15,679
deborah kelly talked about earlier is a

2007
01:18:18,790 --> 01:18:16,800
model uh

2008
01:18:20,950 --> 01:18:18,800
serpentinite hosted system

2009
01:18:22,709 --> 01:18:20,960
so two taxonomically very different

2010
01:18:24,950 --> 01:18:22,719
types of organisms probably different

2011
01:18:26,870 --> 01:18:24,960
orders of acetothermia

2012
01:18:28,550 --> 01:18:26,880
in addition to being taxonomically very

2013
01:18:30,950 --> 01:18:28,560

different they also inhabit different

2014
01:18:33,030 --> 01:18:30,960
ecological niches in the samil ophelite

2015
01:18:35,910 --> 01:18:33,040
along water gradients

2016
01:18:37,910 --> 01:18:35,920
so the type one shown in orange again um

2017
01:18:40,070 --> 01:18:37,920
pretty much only inhabit lower ph types

2018
01:18:41,669 --> 01:18:40,080
of subsurface fluids whereas the type 2

2019
01:18:42,870 --> 01:18:41,679
and blue again pretty much only have

2020
01:18:44,229 --> 01:18:42,880
higher ph

2021
01:18:46,229 --> 01:18:44,239
hyper alkaline fluids in the small

2022
01:18:48,310 --> 01:18:46,239
ophelate these fluids have been referred

2023
01:18:49,990 --> 01:18:48,320
to previously as type 1 lower ph and

2024
01:18:51,270 --> 01:18:50,000
type 2 is higher ph and that's actually

2025
01:18:53,189 --> 01:18:51,280
kind of why i named these different

2026
01:18:54,870 --> 01:18:53,199
populations as they are

2027
01:18:56,709 --> 01:18:54,880
so what that graph there is shown on the

2028
01:18:58,390 --> 01:18:56,719
right is just an estimated relative

2029
01:19:00,870 --> 01:18:58,400
abundance of these two different types

2030
01:19:02,630 --> 01:19:00,880
of acetothermia in different subsurface

2031
01:19:03,750 --> 01:19:02,640
well water communities so each one of

2032
01:19:05,750 --> 01:19:03,760
those different rows is a different

2033
01:19:07,910 --> 01:19:05,760
community the number in parentheses is

2034
01:19:09,910 --> 01:19:07,920
the ph and they're organized by the type

2035
01:19:11,270 --> 01:19:09,920
of rock setting as well as our ph in

2036
01:19:12,950 --> 01:19:11,280
ascending order and so you can see that

2037
01:19:15,510 --> 01:19:12,960
they pretty much have distinct

2038
01:19:17,350 --> 01:19:15,520

distributions along the gradient of of

2039
01:19:20,070 --> 01:19:17,360
water types which again ph is a proxy

2040
01:19:21,430 --> 01:19:20,080
for serpentization influence

2041
01:19:22,470 --> 01:19:21,440
there's really only one community that

2042
01:19:23,910 --> 01:19:22,480
had

2043
01:19:25,830 --> 01:19:23,920
any bit of overlap between these two

2044
01:19:27,910 --> 01:19:25,840
types and it was a sample that was taken

2045
01:19:30,310 --> 01:19:27,920
nearer to the surface from this nshq14

2046
01:19:31,350 --> 01:19:30,320
well from a 50 meter sample

2047
01:19:32,709 --> 01:19:31,360
i won't talk about too much of the

2048
01:19:34,310 --> 01:19:32,719
details of this but there's evidence

2049
01:19:36,390 --> 01:19:34,320
that there's mixing of near surface

2050
01:19:37,750 --> 01:19:36,400
waters in that particular sample that

2051
01:19:39,750 --> 01:19:37,760
you don't find in the deeper sample that

2052
01:19:42,950 --> 01:19:39,760
was taken from 85 meters where you find

2053
01:19:44,470 --> 01:19:42,960
essentially only the type 2 population

2054
01:19:45,990 --> 01:19:44,480
and so what these results suggest is

2055
01:19:47,750 --> 01:19:46,000
that these type 2 acetothermia are much

2056
01:19:49,189 --> 01:19:47,760
better adapted to these deeper hyper

2057
01:19:51,830 --> 01:19:49,199
alkaline waters that are highly

2058
01:19:53,590 --> 01:19:51,840
influenced by serpentization

2059
01:19:55,510 --> 01:19:53,600
so what i really wanted to get at in my

2060
01:19:56,709 --> 01:19:55,520
work is how these organisms are

2061
01:19:59,590 --> 01:19:56,719
potentially adapted to these

2062
01:20:01,350 --> 01:19:59,600
environments and so to do this i used

2063
01:20:02,950 --> 01:20:01,360

metabolic modeling based off the genomes

2064
01:20:04,550 --> 01:20:02,960
that i was able to recover i don't want

2065
01:20:06,550 --> 01:20:04,560
to scare you away with this

2066
01:20:07,750 --> 01:20:06,560
graph that has a bunch of details on it

2067
01:20:09,750 --> 01:20:07,760
i'm just going to talk about some of the

2068
01:20:12,870 --> 01:20:09,760
more prescient a

2069
01:20:13,990 --> 01:20:12,880
couple things here in turn

2070
01:20:15,270 --> 01:20:14,000
and so as i walk through these next

2071
01:20:16,310 --> 01:20:15,280
couple of slides

2072
01:20:17,669 --> 01:20:16,320
you don't really need to worry about the

2073
01:20:19,669 --> 01:20:17,679
enzymatic details of these various

2074
01:20:20,870 --> 01:20:19,679
reactions the type 1 enzymes are always

2075
01:20:22,310 --> 01:20:20,880
going to be an orange type 2 are always

2076
01:20:23,990 --> 01:20:22,320
going to be in blue

2077
01:20:25,910 --> 01:20:24,000
one of the most important things that i

2078
01:20:27,590 --> 01:20:25,920
was able to identify is that they both

2079
01:20:29,350 --> 01:20:27,600
encode the capacity for autotrophic

2080
01:20:31,350 --> 01:20:29,360
acetogenesis using the wood lung daw

2081
01:20:33,669 --> 01:20:31,360
pathway you might also know this is a

2082
01:20:35,590 --> 01:20:33,679
reductive acetyl-coa pathway

2083
01:20:37,430 --> 01:20:35,600
it's been

2084
01:20:39,189 --> 01:20:37,440
invoked as one of the earliest microbial

2085
01:20:41,430 --> 01:20:39,199
carbon fixation pathways

2086
01:20:43,430 --> 01:20:41,440
and a lot of early life research

2087
01:20:44,550 --> 01:20:43,440
they both do this interestingly they do

2088
01:20:46,070 --> 01:20:44,560

it through different enzymatic

2089
01:20:47,350 --> 01:20:46,080
complements suggesting that they

2090
01:20:48,629 --> 01:20:47,360
probably came about this capacity

2091
01:20:50,470 --> 01:20:48,639
through different evolutionary

2092
01:20:51,990 --> 01:20:50,480
trajectories

2093
01:20:53,990 --> 01:20:52,000
it's important to note that the

2094
01:20:55,590 --> 01:20:54,000
woodlongdoll pathway itself is your

2095
01:20:56,870 --> 01:20:55,600
initial carbon fixation step but it

2096
01:20:59,030 --> 01:20:56,880
actually takes a bunch more steps in

2097
01:21:01,030 --> 01:20:59,040
order to get to larger biome

2098
01:21:03,030 --> 01:21:01,040
biomolecules like sugars

2099
01:21:04,629 --> 01:21:03,040
uh indeed these organisms both of them

2100
01:21:07,270 --> 01:21:04,639
were able to encode the capacity for

2101
01:21:09,350 --> 01:21:07,280
autotrophy via gluconeogenesis

2102
01:21:13,030 --> 01:21:09,360
suggesting that they were indeed capable

2103
01:21:16,149 --> 01:21:14,390
there's more differences in terms of

2104
01:21:17,910 --> 01:21:16,159
what they're capable of doing these type

2105
01:21:20,310 --> 01:21:17,920
2 again these are the ones that you find

2106
01:21:22,470 --> 01:21:20,320
in the most hyper alkaline fluids appear

2107
01:21:24,390 --> 01:21:22,480
to be primarily reliant on hydrogen gas

2108
01:21:26,830 --> 01:21:24,400
for their energy conservation pathways

2109
01:21:29,189 --> 01:21:26,840
they encode electron bifurcating

2110
01:21:30,950 --> 01:21:29,199
hydrogenases these are used to produce

2111
01:21:33,270 --> 01:21:30,960
reduced paradoxine ferrodoxin is like a

2112
01:21:34,950 --> 01:21:33,280
low potential electron carrier

2113
01:21:36,629 --> 01:21:34,960

and that then is used to drive a

2114
01:21:38,070 --> 01:21:36,639
chemiosmotic potential through an rnf

2115
01:21:39,750 --> 01:21:38,080
complex and that chemical osmotic

2116
01:21:41,830 --> 01:21:39,760
potential can

2117
01:21:43,830 --> 01:21:41,840
be used for atp synthesis through an

2118
01:21:46,149 --> 01:21:43,840
f-type atp synthase

2119
01:21:47,350 --> 01:21:46,159
i should note that these complexes are

2120
01:21:48,870 --> 01:21:47,360
essentially

2121
01:21:50,629 --> 01:21:48,880
um

2122
01:21:52,149 --> 01:21:50,639
prevalently found in canonical model

2123
01:21:54,550 --> 01:21:52,159
acetogens like acetobacterium in the

2124
01:21:55,830 --> 01:21:54,560
rest so pretty consistent with what

2125
01:21:57,590 --> 01:21:55,840
decades and decades of research of

2126
01:22:00,229 --> 01:21:57,600
acetogens have been covered as their

2127
01:22:01,990 --> 01:22:00,239
energy conservation pathways

2128
01:22:03,510 --> 01:22:02,000
type one on the other hand do not

2129
01:22:06,149 --> 01:22:03,520
apparently occur the capacity to use

2130
01:22:08,390 --> 01:22:06,159
hydrogen gas they might produce hydrogen

2131
01:22:09,750 --> 01:22:08,400
through a biosynthetic pathway

2132
01:22:11,110 --> 01:22:09,760
they are able to produce a chemical

2133
01:22:13,189 --> 01:22:11,120
osmotic potential but through a totally

2134
01:22:15,350 --> 01:22:13,199
different means they don't code rnf they

2135
01:22:16,870 --> 01:22:15,360
cut a bunch of membrane complexes that

2136
01:22:17,910 --> 01:22:16,880
apparently allow them to use other

2137
01:22:20,070 --> 01:22:17,920
oxidants

2138
01:22:22,709 --> 01:22:20,080

for energy conservation like nitrate

2139
01:22:24,229 --> 01:22:22,719
nitrite and potentially oxygen

2140
01:22:26,950 --> 01:22:24,239
and they use a totally different type of

2141
01:22:29,750 --> 01:22:26,960
atp synthase to produce atp it's a

2142
01:22:31,590 --> 01:22:29,760
v-type uh atp synthase

2143
01:22:33,350 --> 01:22:31,600
and so taken together these results

2144
01:22:34,629 --> 01:22:33,360
suggest that these type 2 acetothermia

2145
01:22:35,669 --> 01:22:34,639
are much better adapted to hyper

2146
01:22:37,590 --> 01:22:35,679
alkaline waters that are highly

2147
01:22:39,510 --> 01:22:37,600
influenced by serpentization for

2148
01:22:41,990 --> 01:22:39,520
instance they're pretty much reliant on

2149
01:22:43,910 --> 01:22:42,000
hydrogen gas which again is abundant

2150
01:22:45,270 --> 01:22:43,920
in these types of environments whereas

2151
01:22:47,270 --> 01:22:45,280
these type of cedarothermia that we find

2152
01:22:49,189 --> 01:22:47,280
in the lower ph more oxygen or plate

2153
01:22:51,110 --> 01:22:49,199
waters appear to be capable primarily

2154
01:22:54,709 --> 01:22:51,120
using these oxidants so you find in more

2155
01:22:58,390 --> 01:22:55,590
so

2156
01:22:59,750 --> 01:22:58,400
goals of this work is to try to

2157
01:23:01,030 --> 01:22:59,760
understand the characteristics of these

2158
01:23:02,709 --> 01:23:01,040
organisms that allow them to inhabit

2159
01:23:04,390 --> 01:23:02,719
these environments

2160
01:23:06,629 --> 01:23:04,400
but another aspect of it is to try to

2161
01:23:08,550 --> 01:23:06,639
understand what they can tell us about

2162
01:23:10,550 --> 01:23:08,560
the earliest life on earth and the

2163
01:23:12,310 --> 01:23:10,560

potential for life on other systems

2164
01:23:13,990 --> 01:23:12,320
based on these adaptations and their

2165
01:23:16,149 --> 01:23:14,000
evolutionary histories

2166
01:23:17,669 --> 01:23:16,159
and so andrew took some additional

2167
01:23:19,510 --> 01:23:17,679
phylogenetic analysis to try to get at

2168
01:23:21,750 --> 01:23:19,520
this question first question i wanted to

2169
01:23:22,870 --> 01:23:21,760
ask is where where do they fall out on a

2170
01:23:24,629 --> 01:23:22,880
tree of all

2171
01:23:25,750 --> 01:23:24,639
you know known bacterial lineages so i

2172
01:23:27,830 --> 01:23:25,760
undertook

2173
01:23:29,350 --> 01:23:27,840
a whole bacterial domain genetic

2174
01:23:31,350 --> 01:23:29,360
analysis which is what's being shown in

2175
01:23:32,790 --> 01:23:31,360
this large tree here don't really need

2176
01:23:34,390 --> 01:23:32,800
to worry about any of the names i'm just

2177
01:23:36,229 --> 01:23:34,400
pointing out with that area with that

2178
01:23:38,870 --> 01:23:36,239
arrow where the type 1 and type 2

2179
01:23:40,390 --> 01:23:38,880
acetothermia fall out

2180
01:23:42,149 --> 01:23:40,400
long story short they're essentially

2181
01:23:44,310 --> 01:23:42,159
some of the deepest branching groups

2182
01:23:45,990 --> 01:23:44,320
that have been discovered yet sister to

2183
01:23:48,070 --> 01:23:46,000
others groups the thermotogo synergy

2184
01:23:49,830 --> 01:23:48,080
studies and dienococcus thermos that a

2185
01:23:52,070 --> 01:23:49,840
bunch of other studies have suggested

2186
01:23:54,310 --> 01:23:52,080
the earliest bacteria to have evolved so

2187
01:23:56,229 --> 01:23:54,320
very early branching

2188
01:23:58,870 --> 01:23:56,239

is very highly supported branching

2189
01:24:00,390 --> 01:23:58,880
placement in the tree as well

2190
01:24:02,070 --> 01:24:00,400
and the last little bit that i'll leave

2191
01:24:03,910 --> 01:24:02,080
off of that provide some sort of

2192
01:24:06,149 --> 01:24:03,920
intriguing

2193
01:24:07,830 --> 01:24:06,159
questions regarding uh

2194
01:24:10,070 --> 01:24:07,840
the potential for these organisms to

2195
01:24:11,430 --> 01:24:10,080
serve as analogs for early earth

2196
01:24:15,350 --> 01:24:11,440
is

2197
01:24:17,350 --> 01:24:15,360
for the woodlung dull pathway so these

2198
01:24:21,030 --> 01:24:17,360
are carbon monoxide dehydrogenase acetyl

2199
01:24:22,629 --> 01:24:21,040
coa synthase genes or ca codh acs

2200
01:24:24,709 --> 01:24:22,639
these types have very different types of

2201
01:24:26,149 --> 01:24:24,719
codh acs the type 2 encode an

2202
01:24:27,430 --> 01:24:26,159
archaeal-like

2203
01:24:29,030 --> 01:24:27,440
system whereas the type 1 encode

2204
01:24:30,550 --> 01:24:29,040
bacterial-like system

2205
01:24:32,390 --> 01:24:30,560
what i'm showing here is a phylogeny of

2206
01:24:34,550 --> 01:24:32,400
just the archaeolike the bacterial one

2207
01:24:35,510 --> 01:24:34,560
isn't quite as interesting so i'm just i

2208
01:24:36,790 --> 01:24:35,520
can talk about that later if you're

2209
01:24:38,709 --> 01:24:36,800
interested in it

2210
01:24:40,709 --> 01:24:38,719
what's interesting about the type 2 uh

2211
01:24:42,470 --> 01:24:40,719
codh acs is that it's pretty rare among

2212
01:24:44,390 --> 01:24:42,480
bacteria but i'm drawing your attention

2213
01:24:46,070 --> 01:24:44,400

to where these type 2

2214
01:24:47,830 --> 01:24:46,080
complex subunits fall out in the tree

2215
01:24:48,950 --> 01:24:47,840
with this red star

2216
01:24:50,790 --> 01:24:48,960
essentially

2217
01:24:54,229 --> 01:24:50,800
these type 2

2218
01:24:55,669 --> 01:24:54,239
organisms their cdh acs they encode are

2219
01:24:57,590 --> 01:24:55,679
related to others that are found in

2220
01:24:58,870 --> 01:24:57,600
serpentinite systems

2221
01:25:01,750 --> 01:24:58,880
that have been found at the cedars for

2222
01:25:03,430 --> 01:25:01,760
instance as well as a lost city system

2223
01:25:05,110 --> 01:25:03,440
and they're highly they have a highly

2224
01:25:06,550 --> 01:25:05,120
supported grouping with other type 1

2225
01:25:08,390 --> 01:25:06,560
methanogens which have been thought to

2226
01:25:10,229 --> 01:25:08,400
be some of the earliest

2227
01:25:11,590 --> 01:25:10,239
types of methanogens

2228
01:25:13,110 --> 01:25:11,600
very well supported by the phytogenic

2229
01:25:14,550 --> 01:25:13,120
analysis

2230
01:25:16,709 --> 01:25:14,560
so these results potentially suggest

2231
01:25:18,629 --> 01:25:16,719
that there is uh an ancient transfer of

2232
01:25:20,550 --> 01:25:18,639
an archaeal like codh into subsurface

2233
01:25:22,550 --> 01:25:20,560
bacteria and particularly the types that

2234
01:25:24,629 --> 01:25:22,560
are found in these serpentine systems

2235
01:25:26,390 --> 01:25:24,639
which is an intriguing angle to follow

2236
01:25:28,070 --> 01:25:26,400
up on

2237
01:25:29,910 --> 01:25:28,080
so to wrap this all up

2238
01:25:31,430 --> 01:25:29,920

these types of acetothermia in

2239
01:25:33,590 --> 01:25:31,440
particular are highly abundant and this

2240
01:25:35,709 --> 01:25:33,600
familiophilite subsurface waters that

2241
01:25:37,830 --> 01:25:35,719
have the highest evidence for

2242
01:25:39,590 --> 01:25:37,840
serpentinization influence

2243
01:25:40,790 --> 01:25:39,600
they may be key primary producers in

2244
01:25:42,390 --> 01:25:40,800
some of these deepest waters and

2245
01:25:43,910 --> 01:25:42,400
potentially on others for pentonization

2246
01:25:46,390 --> 01:25:43,920
influence waters globally like the lost

2247
01:25:47,750 --> 01:25:46,400
city hydrothermal system for instance

2248
01:25:49,030 --> 01:25:47,760
i've shown a little bit of phytogenetic

2249
01:25:51,669 --> 01:25:49,040
evidence that suggests that among the

2250
01:25:53,189 --> 01:25:51,679
earliest evolved bacterial city seated

2251
01:25:54,950 --> 01:25:53,199
in is known and they exhibit

2252
01:25:57,110 --> 01:25:54,960
evolutionary signals of deep ancestry of

2253
01:25:58,870 --> 01:25:57,120
these important uh key metabolic genes

2254
01:26:00,310 --> 01:25:58,880
like c-o-d-h-a-c-s

2255
01:26:02,390 --> 01:26:00,320
and i would argue that these are some of

2256
01:26:03,830 --> 01:26:02,400
the best so far characterized analogues

2257
01:26:05,189 --> 01:26:03,840
of seed agents that have been

2258
01:26:06,629 --> 01:26:05,199
hypothesized

2259
01:26:08,229 --> 01:26:06,639
to be among the earliest to evolve on

2260
01:26:10,709 --> 01:26:08,239
earth and serpentine environments and

2261
01:26:13,189 --> 01:26:10,719
they're they're a good

2262
01:26:14,790 --> 01:26:13,199
a good system for future analysis where

2263
01:26:17,350 --> 01:26:14,800

these are of course mostly based off of

2264
01:26:19,510 --> 01:26:17,360
genomic data we saw ongoing cultivation

2265
01:26:21,430 --> 01:26:19,520
efforts in the lab to try to produce

2266
01:26:23,430 --> 01:26:21,440
cultures of these type 2 acetothermia in

2267
01:26:25,110 --> 01:26:23,440
the type 1 for that matter

2268
01:26:26,229 --> 01:26:25,120
been able to generate some acetate

2269
01:26:27,750 --> 01:26:26,239
producing cultures from these hyper

2270
01:26:29,189 --> 01:26:27,760
alkaline waters but

2271
01:26:30,709 --> 01:26:29,199
transfer is a problem with them and so

2272
01:26:33,030 --> 01:26:30,719
it's something we're currently working

2273
01:26:34,870 --> 01:26:33,040
on in the lab

2274
01:26:36,229 --> 01:26:34,880
and so with that i'd like to thank all

2275
01:26:37,830 --> 01:26:36,239
the collaborators this work was done in

2276
01:26:39,590 --> 01:26:37,840
collaboration with alexis's lab at uc

2277
01:26:41,189 --> 01:26:39,600
boulder as well as john spirit carlos

2278
01:26:42,229 --> 01:26:41,199
school minds and all the folks that have

2279
01:26:44,070 --> 01:26:42,239
helped out in the field and other

2280
01:26:45,270 --> 01:26:44,080
aspects of the study and i'd be happy to

2281
01:26:52,790 --> 01:26:45,280
take any questions if there's time for

2282
01:27:01,270 --> 01:26:54,790
thank you dan uh we have time for one

2283
01:27:05,990 --> 01:27:04,229
i didn't tristan cara from cu boulder

2284
01:27:07,750 --> 01:27:06,000
great talk

2285
01:27:09,590 --> 01:27:07,760
i'm curious if you have insights into

2286
01:27:11,510 --> 01:27:09,600
what you think the primary carbon source

2287
01:27:13,590 --> 01:27:11,520
of these organisms uses because as

2288
01:27:15,350 --> 01:27:13,600

alexis talked about these fluids didn't

2289
01:27:17,189 --> 01:27:15,360
have to be really dic limited and so do

2290
01:27:20,550 --> 01:27:17,199
you think that's where the codh comes in

2291
01:27:21,910 --> 01:27:20,560
or their format related

2292
01:27:24,149 --> 01:27:21,920
proteins

2293
01:27:25,430 --> 01:27:24,159
yeah no great question uh alexis alluded

2294
01:27:26,870 --> 01:27:25,440
to dsc is a problem if you're a

2295
01:27:28,070 --> 01:27:26,880
microorganism trying to be an autotroph

2296
01:27:30,390 --> 01:27:28,080
in these systems

2297
01:27:31,910 --> 01:27:30,400
i think it's probably formate they have

2298
01:27:33,270 --> 01:27:31,920
i didn't talk about it just for brevity

2299
01:27:34,790 --> 01:27:33,280
but these type 2 that live in these

2300
01:27:35,910 --> 01:27:34,800
really hyper alkaline fluids have

2301
01:27:37,750 --> 01:27:35,920
reversible

2302
01:27:39,510 --> 01:27:37,760
electron bifurcating for forming

2303
01:27:41,910 --> 01:27:39,520
dehydrogenases so they can interconvert

2304
01:27:43,510 --> 01:27:41,920
between co2 and formate pretty readily i

2305
01:27:45,430 --> 01:27:43,520
think that's probably the the best guess

2306
01:27:48,390 --> 01:27:45,440
for what they're using

2307
01:27:56,870 --> 01:27:49,510
yep

2308
01:28:00,550 --> 01:27:59,189
so alexis

2309
01:28:03,030 --> 01:28:00,560
touched on this a little bit and i've

2310
01:28:05,669 --> 01:28:03,040
heard about it from other people um

2311
01:28:07,590 --> 01:28:05,679
that the contact between the peridotites

2312
01:28:09,350 --> 01:28:07,600
and the gabbros are

2313
01:28:11,910 --> 01:28:09,360

you know sort of a hot spot and

2314
01:28:15,030 --> 01:28:11,920
certainly the the cell numbers

2315
01:28:17,590 --> 01:28:15,040
indicate that you know i'm curious about

2316
01:28:18,870 --> 01:28:17,600
the the acetogens and if that if they're

2317
01:28:20,790 --> 01:28:18,880
playing

2318
01:28:22,229 --> 01:28:20,800
along that gradient but what is it i

2319
01:28:23,990 --> 01:28:22,239
guess the question is what is it about

2320
01:28:25,189 --> 01:28:24,000
the gradient and the

2321
01:28:27,830 --> 01:28:25,199
contact

2322
01:28:30,629 --> 01:28:27,840
that makes it so special

2323
01:28:32,629 --> 01:28:30,639
that's a good question um and i think

2324
01:28:34,149 --> 01:28:32,639
just from my perspective i think

2325
01:28:35,830 --> 01:28:34,159
the evidence suggests that it's probably

2326
01:28:36,950 --> 01:28:35,840
mixing of different water type fluids

2327
01:28:38,790 --> 01:28:36,960
right

2328
01:28:40,229 --> 01:28:38,800
when that talk

2329
01:28:41,910 --> 01:28:40,239
about prony bay and some of the others

2330
01:28:42,950 --> 01:28:41,920
as well it's it's really the mixing of

2331
01:28:44,629 --> 01:28:42,960
two different fluids where you get

2332
01:28:46,149 --> 01:28:44,639
reductants and oxidants and you know

2333
01:28:47,830 --> 01:28:46,159
once you have that combination of things

2334
01:28:50,390 --> 01:28:47,840
things can just totally take off in

2335
01:28:52,950 --> 01:28:50,400
terms of what's capable in those systems

2336
01:28:53,910 --> 01:28:52,960
um personally i think that's that's kind

2337
01:28:55,669 --> 01:28:53,920
of what's driving a lot of the

2338
01:28:57,990 --> 01:28:55,679

productivity and those sort of mixed

2339
01:28:59,990 --> 01:28:58,000
contact types of settings and i think

2340
01:29:01,990 --> 01:29:00,000
libby alluded to that in some of her

2341
01:29:03,350 --> 01:29:02,000
work as well and uh

2342
01:29:05,430 --> 01:29:03,360
and yeah and probably why you don't get

2343
01:29:06,950 --> 01:29:05,440
as much productivity in the deeper

2344
01:29:08,390 --> 01:29:06,960
waters where there's no mixing right

2345
01:29:10,229 --> 01:29:08,400
it's just highly reducing there's no

2346
01:29:11,350 --> 01:29:10,239
oxidants

2347
01:29:13,189 --> 01:29:11,360
you know you have things that are

2348
01:29:15,270 --> 01:29:13,199
probably doing these really simple

2349
01:29:16,950 --> 01:29:15,280
pathways where there's just no no

2350
01:29:19,110 --> 01:29:16,960
oxidants really available to drive

2351
01:29:22,070 --> 01:29:19,120
anything

2352
01:29:26,950 --> 01:29:24,629
thank you very much all right that

2353
01:29:28,390 --> 01:29:26,960
concludes our session thank you all for

2354
01:29:30,950 --> 01:29:28,400
attending and thank you again to our

2355
01:29:33,510 --> 01:29:30,960
speakers the fun doesn't stop here

2356
01:29:35,910 --> 01:29:33,520
though we have another online session at

2357
01:29:38,070 --> 01:29:35,920
2 30 so i encourage you to come to that

2358
01:29:39,910 --> 01:29:38,080
and then we also have a poster session

2359
01:29:40,870 --> 01:29:39,920
we have a lot of posters and they're all

2360
01:29:43,270 --> 01:29:40,880
awesome

2361
01:29:45,030 --> 01:29:43,280
and that's at 4 30 today so thank you