Serpentinizing Systems Science

NASA Workshop Without Walls

1
00:00:05,190 --> 00:00:02,230
welcome everybody to day two of the

2
00:00:07,590 --> 00:00:05,200
stompatomizing systems science workshop

3
00:00:10,070 --> 00:00:07,600
i was asked to provide a quick recap of

4
00:00:12,230 --> 00:00:10,080
what we talked about on day one

5
00:00:13,990 --> 00:00:12,240
and uh to do that i

6
00:00:16,870 --> 00:00:14,000
i'm going to use notes taken by katrina

7
00:00:18,070 --> 00:00:16,880
tuing who's a postdoc in our lab she is

8
00:00:20,150 --> 00:00:18,080
dealing with other things this morning

9
00:00:21,029 --> 00:00:20,160
she'll be joining us later so i'm going

10
00:00:23,750 --> 00:00:21,039
to

11
00:00:24,710 --> 00:00:23,760
uh present a synthesis of the notes that

12
00:00:27,830 --> 00:00:24,720
she took

13
00:00:30,390 --> 00:00:27,840

so day one was dependentization systems

14
00:00:31,910 --> 00:00:30,400
on earth so actual field

15
00:00:33,350 --> 00:00:31,920
sites on earth where we are studying

16
00:00:35,910 --> 00:00:33,360
supernaturalization and they talked

17
00:00:37,030 --> 00:00:35,920
about sites on the seafloor and sites on

18
00:00:39,350 --> 00:00:37,040
continents

19
00:00:40,229 --> 00:00:39,360
and each of our invited talks talked

20
00:00:42,549 --> 00:00:40,239
about

21
00:00:44,950 --> 00:00:42,559
aspects of those

22
00:00:47,110 --> 00:00:44,960
so first we heard from susan lang

23
00:00:49,350 --> 00:00:47,120
uh who mostly talked about lost city an

24
00:00:50,869 --> 00:00:49,360
example of a circulationizing system on

25
00:00:51,910 --> 00:00:50,879
the seafloor

26
00:00:55,830 --> 00:00:51,920
she

27
00:00:58,150 --> 00:00:55,840
focused on carbon chemistry of what

28
00:01:00,470 --> 00:00:58,160
we infer to be a single in-member

29
00:01:01,590 --> 00:01:00,480
subsurface fluid supplying velocity

30
00:01:03,110 --> 00:01:01,600
jimmy

31
00:01:05,350 --> 00:01:03,120
she talks about how inorganic carbon

32
00:01:08,230 --> 00:01:05,360
like carbon dioxide is very low in the

33
00:01:10,550 --> 00:01:08,240
high ph velocity chimney fluids

34
00:01:12,390 --> 00:01:10,560
which also seems to be a general trend

35
00:01:13,910 --> 00:01:12,400
of most of feminizing systems we've

36
00:01:15,749 --> 00:01:13,920
looked at so far

37
00:01:17,510 --> 00:01:15,759
and so instead organic carbon is much

38
00:01:18,469 --> 00:01:17,520

more common than inorganic carbon energy

39
00:01:20,310 --> 00:01:18,479
systems

40
00:01:22,070 --> 00:01:20,320
which is kind of upside down from all

41
00:01:23,749 --> 00:01:22,080
other ecosystems that basically has ever

42
00:01:24,469 --> 00:01:23,759
been studied

43
00:01:27,910 --> 00:01:24,479
she

44
00:01:29,510 --> 00:01:27,920
provided evidence based on c13 c14

45
00:01:31,429 --> 00:01:29,520
isotopes so which of these carbon

46
00:01:34,069 --> 00:01:31,439
compounds may be produced

47
00:01:35,910 --> 00:01:34,079
non-biologically or abiotically which is

48
00:01:38,230 --> 00:01:35,920
important for origin of life and

49
00:01:39,749 --> 00:01:38,240
astrobiological purposes

50
00:01:41,749 --> 00:01:39,759
talks about formate and methane are

51
00:01:43,990 --> 00:01:41,759
almost certainly produced by

52
00:01:45,429 --> 00:01:44,000
serpentization reactions abiotically

53
00:01:46,950 --> 00:01:45,439
although that doesn't rule out that

54
00:01:49,749 --> 00:01:46,960
methane for example could also be

55
00:01:51,429 --> 00:01:49,759
produced by organisms to some degree

56
00:01:54,149 --> 00:01:51,439
some alkanes are probably being produced

57
00:01:56,469 --> 00:01:54,159
abiotically whereas other carbon

58
00:01:57,910 --> 00:01:56,479
compounds like acetate and amino acids

59
00:02:01,190 --> 00:01:57,920
appear to be

60
00:02:03,109 --> 00:02:01,200
mostly produced biologically and lost

61
00:02:05,749 --> 00:02:03,119
according to the data that susan and

62
00:02:08,869 --> 00:02:05,759
others have looked at so far

63
00:02:11,190 --> 00:02:08,879

so then we heard from

64
00:02:13,589 --> 00:02:11,200
everett shock who used this male

65
00:02:16,630 --> 00:02:13,599
ophilite and oman as an example of

66
00:02:18,070 --> 00:02:16,640
sequentialization on consonants

67
00:02:20,309 --> 00:02:18,080
he talked about how the hydrogen

68
00:02:22,790 --> 00:02:20,319
concentrations and the wells drilled

69
00:02:25,270 --> 00:02:22,800
into the surfactants in oman are highly

70
00:02:26,470 --> 00:02:25,280
variable which suggests this biological

71
00:02:29,030 --> 00:02:26,480
consumption

72
00:02:30,550 --> 00:02:29,040
so there's ongoing research into that

73
00:02:33,270 --> 00:02:30,560
ever talked about how calculating

74
00:02:36,229 --> 00:02:33,280
potential energy available from chemical

75
00:02:37,430 --> 00:02:36,239
reactions using actual chemical

76
00:02:39,509 --> 00:02:37,440
measurements of the environmental

77
00:02:41,750 --> 00:02:39,519
conditions can constrain which metabolic

78
00:02:43,430 --> 00:02:41,760
strategies by life we would expect to be

79
00:02:45,110 --> 00:02:43,440
occurring there

80
00:02:46,630 --> 00:02:45,120
uh he talked about how

81
00:02:52,550 --> 00:02:46,640
these systems seem to have a lot of

82
00:02:56,309 --> 00:02:53,270
are

83
00:02:57,750 --> 00:02:56,319
providing a lot of electrons for

84
00:02:58,869 --> 00:02:57,760
metabolic

85
00:03:01,509 --> 00:02:58,879
pathways

86
00:03:04,229 --> 00:03:01,519
and so it might be that the availability

87
00:03:06,710 --> 00:03:04,239
of electron acceptors like oxygen

88
00:03:08,470 --> 00:03:06,720

nitrate sulfates might be

89
00:03:10,149 --> 00:03:08,480
determining where

90
00:03:11,509 --> 00:03:10,159
microbial activity is most prevalent at

91
00:03:13,030 --> 00:03:11,519
least that was my interpretation of

92
00:03:15,110 --> 00:03:13,040
everett's talk if you can correct me if

93
00:03:17,589 --> 00:03:15,120
i didn't get that quite right

94
00:03:19,509 --> 00:03:17,599
and ever i talked about how my

95
00:03:21,750 --> 00:03:19,519
does not appear to be favorable based on

96
00:03:23,270 --> 00:03:21,760
the measurements that have been made um

97
00:03:25,270 --> 00:03:23,280
but he talked about maybe that's because

98
00:03:27,350 --> 00:03:25,280
methanogenesis already occurred in the

99
00:03:28,550 --> 00:03:27,360
subsurface and therefore doesn't seem

100
00:03:30,229 --> 00:03:28,560
very verbal

101
00:03:33,270 --> 00:03:30,239
in the places that we actually measure

102
00:03:34,869 --> 00:03:33,280
after it's already happened

103
00:03:36,949 --> 00:03:34,879
i see a question in the chat window to

104
00:03:38,470 --> 00:03:36,959
ask me to clarify that sequentialization

105
00:03:40,789 --> 00:03:38,480
directly does not actually produce

106
00:03:43,110 --> 00:03:40,799
methane that's right a lot of

107
00:03:44,630 --> 00:03:43,120
people like me

108
00:03:46,470 --> 00:03:44,640
who are

109
00:03:48,710 --> 00:03:46,480
not as geochemically precise

110
00:03:50,390 --> 00:03:48,720
use serpentinization as a catch-all word

111
00:03:51,190 --> 00:03:50,400
for a lot of

112
00:03:53,350 --> 00:03:51,200
uh

113
00:03:56,630 --> 00:03:53,360

reactions that are occurring

114
00:03:58,470 --> 00:03:56,640
in mr pentonite-like environment so yeah

115
00:04:00,470 --> 00:03:58,480
separatisation does not directly create

116
00:04:02,630 --> 00:04:00,480
methane as i'm sure we're going to hear

117
00:04:04,309 --> 00:04:02,640
a lot more about that today so methane

118
00:04:06,229 --> 00:04:04,319
is produced

119
00:04:07,990 --> 00:04:06,239
by other reactions that are occurring in

120
00:04:10,309 --> 00:04:08,000
these environments maybe not directly by

121
00:04:16,069 --> 00:04:10,319
speculation okay thank you but i'm sure

122
00:04:20,390 --> 00:04:17,909
uh that was matt uh everett then we

123
00:04:21,990 --> 00:04:20,400
heard about matt who also uh mostly

124
00:04:24,230 --> 00:04:22,000
talked about continental systems also

125
00:04:25,510 --> 00:04:24,240
talked about marine separation systems

126
00:04:27,590 --> 00:04:25,520
as well

127
00:04:30,550 --> 00:04:27,600
uh he talked about how

128
00:04:32,870 --> 00:04:30,560
we've only studied a very small

129
00:04:34,629 --> 00:04:32,880
percentage of all the places where

130
00:04:36,310 --> 00:04:34,639
stephen knights are found there are

131
00:04:38,150 --> 00:04:36,320
potentially hundreds more places that we

132
00:04:39,909 --> 00:04:38,160
could go around to study which is an

133
00:04:42,390 --> 00:04:39,919
inspiring thought

134
00:04:44,550 --> 00:04:42,400
he talked about how continental systems

135
00:04:46,790 --> 00:04:44,560
one advantage of them is that they have

136
00:04:49,270 --> 00:04:46,800
lots of variations in climate hydrology

137
00:04:51,749 --> 00:04:49,280
chemistry geology and use one example of

138
00:04:52,710 --> 00:04:51,759

the santa elena ophelia in costa rica

139
00:04:54,710 --> 00:04:52,720
where

140
00:04:56,390 --> 00:04:54,720
the weather there creates a lot of

141
00:04:57,909 --> 00:04:56,400
extreme wet and dry cycles that might

142
00:04:59,510 --> 00:04:57,919
give us clues into understanding the

143
00:05:01,189 --> 00:04:59,520
hydrology and other aspects of that

144
00:05:02,550 --> 00:05:01,199
system that's an advantage of

145
00:05:06,469 --> 00:05:02,560
continental systems rather than the

146
00:05:12,230 --> 00:05:08,870
he and everett also highlighted the fact

147
00:05:13,990 --> 00:05:12,240
that we have very little evidence

148
00:05:16,070 --> 00:05:14,000
of

149
00:05:18,310 --> 00:05:16,080
real live organisms that we can grow in

150
00:05:20,629 --> 00:05:18,320
the lab from fentonizing systems most of

151
00:05:21,749 --> 00:05:20,639
our biological evidence comes from

152
00:05:24,230 --> 00:05:21,759
sequencing

153
00:05:25,270 --> 00:05:24,240
dna molecules which have their pros and

154
00:05:27,749 --> 00:05:25,280
cons

155
00:05:28,870 --> 00:05:27,759
one exception is this organism that has

156
00:05:31,590 --> 00:05:28,880
been named

157
00:05:33,270 --> 00:05:31,600
sepentinomus

158
00:05:34,230 --> 00:05:33,280
which we call a candidate because it

159
00:05:36,230 --> 00:05:34,240
doesn't

160
00:05:39,350 --> 00:05:36,240
may not have official taxonomic standing

161
00:05:41,590 --> 00:05:39,360
quite yet but it will soon i'm sure

162
00:05:44,150 --> 00:05:41,600
uh it's aerobic so it may not be the

163
00:05:47,350 --> 00:05:44,160

best example of the deepest most extreme

164
00:05:48,469 --> 00:05:47,360
anoxic uh inhabitants of the subsurface

165
00:05:50,710 --> 00:05:48,479
but

166
00:05:52,950 --> 00:05:50,720
uh appears to be found in a moment in

167
00:05:54,629 --> 00:05:52,960
every serpentizing system that i know of

168
00:05:57,029 --> 00:05:54,639
it consumes hydrogen so it's clearly

169
00:05:59,189 --> 00:05:57,039
related to serpentinization in some way

170
00:06:01,350 --> 00:05:59,199
and there was some discussion yesterday

171
00:06:02,950 --> 00:06:01,360
about whether it could use solid

172
00:06:07,670 --> 00:06:02,960
carbonate as a carbon source which would

173
00:06:10,950 --> 00:06:07,680
be unprecedented as far as i know um

174
00:06:12,950 --> 00:06:10,960
life at high ph uh is a big challenge as

175
00:06:15,510 --> 00:06:12,960
matt talked about and the combination of

176
00:06:17,270 --> 00:06:15,520
high ph and very low ions is that

177
00:06:19,749 --> 00:06:17,280
there's a double challenge

178
00:06:22,230 --> 00:06:19,759
a lot of the fertilizing systems on

179
00:06:23,990 --> 00:06:22,240
complements a very very very low

180
00:06:26,150 --> 00:06:24,000
conductivity low salinity little ionic

181
00:06:27,990 --> 00:06:26,160
strikers they're very very pure and high

182
00:06:29,510 --> 00:06:28,000
ph at the same time

183
00:06:31,749 --> 00:06:29,520
which makes them very different than for

184
00:06:33,590 --> 00:06:31,759
example alkaline lakes which have tons

185
00:06:35,510 --> 00:06:33,600
and tons of ions as well as being

186
00:06:37,510 --> 00:06:35,520
alkaline so

187
00:06:39,510 --> 00:06:37,520
that might be why we have we see very

188
00:06:41,830 --> 00:06:39,520

low biomass in these systems but these

189
00:06:43,590 --> 00:06:41,840
are mostly just speculation

190
00:06:45,350 --> 00:06:43,600
and that also touched on

191
00:06:48,230 --> 00:06:45,360
some of the many interesting connections

192
00:06:52,629 --> 00:06:48,240
to origin of life that specimizing

193
00:06:56,790 --> 00:06:54,230
and then beth was our fourth invited

194
00:07:00,150 --> 00:06:56,800
talk yesterday she talked about an

195
00:07:01,830 --> 00:07:00,160
expedition late 2015

196
00:07:03,909 --> 00:07:01,840
international ocean discovery program

197
00:07:05,670 --> 00:07:03,919
exhibition 357 that went to atlantis

198
00:07:07,430 --> 00:07:05,680
massif which is the giant underwater

199
00:07:10,469 --> 00:07:07,440
mountain where

200
00:07:14,390 --> 00:07:10,479
lost city is located

201
00:07:18,070 --> 00:07:15,270
okay

202
00:07:22,629 --> 00:07:20,230
the uh

203
00:07:24,870 --> 00:07:22,639
she where we drilled into the rocks next

204
00:07:26,870 --> 00:07:24,880
to a city

205
00:07:29,350 --> 00:07:26,880
in order to try to get some

206
00:07:31,110 --> 00:07:29,360
uh more subsurface and some direct

207
00:07:33,510 --> 00:07:31,120
access to subsurface rocks instead of

208
00:07:35,270 --> 00:07:33,520
going through the the window and the

209
00:07:36,309 --> 00:07:35,280
prism of the lost city chimneys which

210
00:07:37,830 --> 00:07:36,319
may or may not be the most

211
00:07:38,950 --> 00:07:37,840
representative

212
00:07:40,790 --> 00:07:38,960
of

213
00:07:42,469 --> 00:07:40,800

a more widespread

214
00:07:44,629 --> 00:07:42,479
form of stabilization on a spatial and

215
00:07:46,629 --> 00:07:44,639
volume basis so those rocks were

216
00:07:48,070 --> 00:07:46,639
recovered from the seafloor using seabed

217
00:07:49,749 --> 00:07:48,080
rock drills instead of a really long

218
00:07:51,110 --> 00:07:49,759
drill string that is typically used for

219
00:07:52,950 --> 00:07:51,120
ocean drilling

220
00:07:54,550 --> 00:07:52,960
which may or may not have interesting

221
00:07:57,270 --> 00:07:54,560
lessons to learn for

222
00:07:59,110 --> 00:07:57,280
explorations on other planets

223
00:08:00,230 --> 00:07:59,120
that would be fun to talk about

224
00:08:01,830 --> 00:08:00,240
uh

225
00:08:03,830 --> 00:08:01,840
they did notice already that there were

226
00:08:05,189 --> 00:08:03,840
bubbles and water flowing out of the

227
00:08:07,510 --> 00:08:05,199
drill holes and they drilled into the

228
00:08:09,350 --> 00:08:07,520
fence which was really exciting there's

229
00:08:10,469 --> 00:08:09,360
a possibility that lots of stuff was

230
00:08:12,950 --> 00:08:10,479
going on

231
00:08:15,589 --> 00:08:12,960
and expedition is still in moratorium uh

232
00:08:18,070 --> 00:08:15,599
still in the one year um

233
00:08:20,550 --> 00:08:18,080
phase of of that uh although that is

234
00:08:21,990 --> 00:08:20,560
ending soon so hopefully we'll be able

235
00:08:26,469 --> 00:08:22,000
to report some results from that

236
00:08:31,350 --> 00:08:29,189
and then here i've captured some of the

237
00:08:34,070 --> 00:08:31,360
topics that were discussed by the pop-up

238
00:08:36,149 --> 00:08:34,080

talks and the questions that were asked

239
00:08:37,750 --> 00:08:36,159
and discussions that were going on in

240
00:08:38,949 --> 00:08:37,760
the chat window

241
00:08:40,469 --> 00:08:38,959
as a way of

242
00:08:45,350 --> 00:08:40,479
recording and capturing that and

243
00:08:48,630 --> 00:08:46,949
katie talked about

244
00:08:51,509 --> 00:08:48,640
how different classes of synthetizing

245
00:08:54,150 --> 00:08:51,519
fluids in oman have distinct microbes

246
00:08:56,310 --> 00:08:54,160
alberto talked about hydrogen methane

247
00:08:57,910 --> 00:08:56,320
being released from fluid inclusions and

248
00:09:00,790 --> 00:08:57,920
deep rocks

249
00:09:02,310 --> 00:09:00,800
uh darn dawn talked about her her fresh

250
00:09:04,070 --> 00:09:02,320
off the field book results from moose to

251
00:09:05,750 --> 00:09:04,080
feminine springs in the philippines and

252
00:09:08,790 --> 00:09:05,760
annie talked about

253
00:09:11,430 --> 00:09:08,800
trying to cultivate and capture microbes

254
00:09:12,870 --> 00:09:11,440
by colonizing them on electrodes

255
00:09:14,070 --> 00:09:12,880
in a shallow shape at night pool in

256
00:09:15,110 --> 00:09:14,080
california

257
00:09:17,110 --> 00:09:15,120
and then

258
00:09:18,949 --> 00:09:17,120
the other boxes are other topics that

259
00:09:21,829 --> 00:09:18,959
were discussed in the chat window a lot

260
00:09:23,829 --> 00:09:21,839
of excitement about the possibility of

261
00:09:25,030 --> 00:09:23,839
biological iron oxide reduction for

262
00:09:27,990 --> 00:09:25,040
example

263
00:09:29,110 --> 00:09:28,000

and how we could calculate or explore

264
00:09:29,910 --> 00:09:29,120
that

265
00:09:31,030 --> 00:09:29,920
and

266
00:09:33,269 --> 00:09:31,040
um

267
00:09:35,190 --> 00:09:33,279
yeah i don't need to to to read all

268
00:09:36,630 --> 00:09:35,200
these i just wanted to recognize all the

269
00:09:39,269 --> 00:09:36,640
fun stuff that was being discussed

270
00:09:44,389 --> 00:09:40,949
so i will

271
00:09:49,190 --> 00:09:46,389
reusing this slide that i used at the

272
00:09:50,949 --> 00:09:49,200
beginning of yesterday as

273
00:09:54,310 --> 00:09:50,959
a perhaps simplistic way to think about

274
00:09:57,190 --> 00:09:54,320
how these sites on earth could be could

275
00:09:59,030 --> 00:09:57,200
help could help inform explorations of

276
00:09:59,990 --> 00:09:59,040
potentials to put night sites on other

277
00:10:02,069 --> 00:10:00,000
planets

278
00:10:05,750 --> 00:10:02,079
which is a basic intellectual challenge

279
00:10:08,150 --> 00:10:05,760
that for the most part um we are limited

280
00:10:10,710 --> 00:10:08,160
by what we can measure on the surface

281
00:10:12,790 --> 00:10:10,720
even when we drill into

282
00:10:14,310 --> 00:10:12,800
rocks we are

283
00:10:15,910 --> 00:10:14,320
we've basically now created a new

284
00:10:17,430 --> 00:10:15,920
surface environment that we are still

285
00:10:19,350 --> 00:10:17,440
measuring some ways you can never really

286
00:10:21,350 --> 00:10:19,360
get around the fact that you are

287
00:10:23,110 --> 00:10:21,360
measuring the surface because we are not

288
00:10:24,949 --> 00:10:23,120

subsurface organisms

289
00:10:26,790 --> 00:10:24,959
so that's always a challenge how do we

290
00:10:28,310 --> 00:10:26,800
infer what is really going on in the

291
00:10:30,310 --> 00:10:28,320
subsurface and

292
00:10:33,430 --> 00:10:30,320
whether there may be

293
00:10:35,750 --> 00:10:33,440
some strange green slime

294
00:10:38,310 --> 00:10:35,760
down in the subsurface that we can't see

295
00:10:40,470 --> 00:10:38,320
and how can we infer what it is doing by

296
00:10:41,910 --> 00:10:40,480
measuring stuff that is leaking out into

297
00:10:43,990 --> 00:10:41,920
the surface that's what we do on the

298
00:10:45,509 --> 00:10:44,000
seafloor what we do on land and

299
00:10:48,069 --> 00:10:45,519
hopefully we'll be able to do another

300
00:10:49,430 --> 00:10:48,079
planet soon

301
00:10:52,150 --> 00:10:49,440
um

302
00:10:54,550 --> 00:10:52,160
yeah i will

303
00:10:56,470 --> 00:10:54,560
stop there and

304
00:11:03,750 --> 00:10:56,480
make way for all the new exciting stuff

305
00:11:06,710 --> 00:11:05,910
okay well i think i will take over then

306
00:11:11,350 --> 00:11:06,720
uh

307
00:11:13,430 --> 00:11:11,360
me i'm tom mccollum a research scientist

308
00:11:15,990 --> 00:11:13,440
at the university of colorado and i'm

309
00:11:16,870 --> 00:11:16,000
going to be the host for today's uh

310
00:11:18,710 --> 00:11:16,880
session

311
00:11:21,509 --> 00:11:18,720
uh thank you billy for giving us that

312
00:11:22,870 --> 00:11:21,519
recap from yesterday and i uh just

313
00:11:25,430 --> 00:11:22,880

wanted to remind you that these are

314
00:11:26,949 --> 00:11:25,440
these uh presentations or our sessions

315
00:11:28,870 --> 00:11:26,959
are going to all be recorded and i think

316
00:11:31,750 --> 00:11:28,880
are going to be made available

317
00:11:33,750 --> 00:11:31,760
on the nai website so if if there's

318
00:11:35,910 --> 00:11:33,760
something you saw there that you haven't

319
00:11:37,910 --> 00:11:35,920
missed yesterday you can i'd encourage

320
00:11:41,430 --> 00:11:37,920
you to go there and look at

321
00:11:44,150 --> 00:11:41,440
and review that information there

322
00:11:47,190 --> 00:11:44,160
so uh i'm gonna start with uh giving a

323
00:11:50,230 --> 00:11:47,200
bit of a of an of uh of an intro to

324
00:11:52,150 --> 00:11:50,240
today's session uh to sort of set the

325
00:11:53,990 --> 00:11:52,160
stage for what's gonna be happening

326
00:11:56,310 --> 00:11:54,000
later on today so i was asked to

327
00:11:59,269 --> 00:11:56,320
organize a session that they covered the

328
00:12:01,910 --> 00:11:59,279
areas of experiments models and uh

329
00:12:03,430 --> 00:12:01,920
and things related to that and uh of

330
00:12:06,069 --> 00:12:03,440
course just

331
00:12:08,870 --> 00:12:06,079
either one of those talk topics could by

332
00:12:11,590 --> 00:12:08,880
itself take a full day of a session a

333
00:12:13,430 --> 00:12:11,600
full week of session maybe uh

334
00:12:15,829 --> 00:12:13,440
so we're really not going to be able to

335
00:12:17,110 --> 00:12:15,839
do more than just touch on a few aspects

336
00:12:20,310 --> 00:12:17,120
of these uh

337
00:12:22,629 --> 00:12:20,320
uh topics and uh so we have a

338
00:12:26,389 --> 00:12:22,639

set of four sp invited speakers and some

339
00:12:29,829 --> 00:12:26,399
contributed uh talks at the end

340
00:12:32,470 --> 00:12:29,839
so i'll just get started and and uh give

341
00:12:34,629 --> 00:12:32,480
a little bit of an introduction then so

342
00:12:36,069 --> 00:12:34,639
i think everybody uh that's tuned in

343
00:12:38,069 --> 00:12:36,079
here is probably familiar with this

344
00:12:39,110 --> 00:12:38,079
general idea of serpentization where you

345
00:12:43,350 --> 00:12:39,120
have a

346
00:12:45,110 --> 00:12:43,360
a a mantle peridotite rock that uh

347
00:12:47,430 --> 00:12:45,120
composed of the minerals olivine and

348
00:12:49,990 --> 00:12:47,440
pyroxene that reacts with water to

349
00:12:52,550 --> 00:12:50,000
become the serpentine sweet a mineral

350
00:12:55,030 --> 00:12:52,560
serpentine some brew site magnetite and

351
00:12:57,670 --> 00:12:55,040
maybe some other stuff along with that

352
00:12:59,509 --> 00:12:57,680
but as astrobiologists we're really most

353
00:13:02,470 --> 00:12:59,519
interested in these other products shown

354
00:13:04,150 --> 00:13:02,480
here hydrogen methane uh maybe some

355
00:13:05,829 --> 00:13:04,160
organics kind of things that can feed

356
00:13:09,829 --> 00:13:05,839
biology

357
00:13:12,069 --> 00:13:09,839
could perhaps provide some kind of

358
00:13:13,190 --> 00:13:12,079
molecules that could feed into an origin

359
00:13:14,389 --> 00:13:13,200
of life

360
00:13:15,910 --> 00:13:14,399
those are the kinds of things that we're

361
00:13:19,190 --> 00:13:15,920
really focused in when we're talking

362
00:13:21,190 --> 00:13:19,200
about astrobiology implications of these

363
00:13:23,509 --> 00:13:21,200

these systems

364
00:13:25,590 --> 00:13:23,519
so i've written here the kind of a a

365
00:13:27,430 --> 00:13:25,600
chemical reaction a general chemical

366
00:13:29,190 --> 00:13:27,440
reaction to represent this process where

367
00:13:31,350 --> 00:13:29,200
we have olivine empirically interact

368
00:13:33,030 --> 00:13:31,360
with water become these serpent night

369
00:13:35,509 --> 00:13:33,040
minerals

370
00:13:37,829 --> 00:13:35,519
and again the key thing that we're

371
00:13:40,629 --> 00:13:37,839
looking at in terms of of uh

372
00:13:42,069 --> 00:13:40,639
astrobiology is production of hydrogen

373
00:13:44,150 --> 00:13:42,079
the production of hydrogen in these

374
00:13:46,069 --> 00:13:44,160
rocks is really closely linked to what

375
00:13:48,550 --> 00:13:46,079
happens with the iron because it's the

376
00:13:51,269 --> 00:13:48,560
conversion pro of of uh

377
00:13:53,910 --> 00:13:51,279
of an iron uh ferric ferrous iron

378
00:13:55,829 --> 00:13:53,920
mineral to a ferric iron mineral uh

379
00:13:57,670 --> 00:13:55,839
reacting with water that is what

380
00:13:59,430 --> 00:13:57,680
produces the hydrogen so if you want to

381
00:14:01,030 --> 00:13:59,440
think about hydrogen production in these

382
00:14:02,470 --> 00:14:01,040
kind of environments in order to feed

383
00:14:05,030 --> 00:14:02,480
biology

384
00:14:07,189 --> 00:14:05,040
uh you really uh have to link that up

385
00:14:09,509 --> 00:14:07,199
with what happens with the iron

386
00:14:11,350 --> 00:14:09,519
uh the other process that may be

387
00:14:12,870 --> 00:14:11,360
going on of interest to bio uh

388
00:14:15,030 --> 00:14:12,880

astrobiology is the production of

389
00:14:17,430 --> 00:14:15,040
methane and conventionally people

390
00:14:20,150 --> 00:14:17,440
usually think about this as being formed

391
00:14:21,990 --> 00:14:20,160
in these systems by reaction of co2 uh

392
00:14:24,069 --> 00:14:22,000
with hydrogen to produce the methane

393
00:14:26,550 --> 00:14:24,079
although other uh pathways might be

394
00:14:28,310 --> 00:14:26,560
possible uh we heard for example

395
00:14:30,550 --> 00:14:28,320
instance at the end of the session

396
00:14:33,269 --> 00:14:30,560
yesterday from uh

397
00:14:35,910 --> 00:14:33,279
about alberto about a maybe a different

398
00:14:38,550 --> 00:14:35,920
pathway for methane formation

399
00:14:40,550 --> 00:14:38,560
uh but this uh reduction of co2 to

400
00:14:43,189 --> 00:14:40,560
hydrogen this is something that can be

401
00:14:45,990 --> 00:14:43,199
done abiotically in these systems but it

402
00:14:48,310 --> 00:14:46,000
also is a potential food source for

403
00:14:50,790 --> 00:14:48,320
methanogenic organisms

404
00:14:52,230 --> 00:14:50,800
so really a lot of the uh stuff that

405
00:14:53,350 --> 00:14:52,240
we're going to hear be hearing about

406
00:14:55,990 --> 00:14:53,360
today

407
00:14:57,430 --> 00:14:56,000
to some extent is is concerned with how

408
00:14:59,509 --> 00:14:57,440
you make these things particularly

409
00:15:03,189 --> 00:14:59,519
focusing on hydrogen

410
00:15:05,269 --> 00:15:03,199
as a as a food source and really

411
00:15:07,269 --> 00:15:05,279
what what constrains how much hydrogen

412
00:15:08,310 --> 00:15:07,279
and where it's produced

413
00:15:09,870 --> 00:15:08,320

so we

414
00:15:12,069 --> 00:15:09,880
think about this reaction as being

415
00:15:14,230 --> 00:15:12,079
relatively simple i mean you're reacting

416
00:15:15,750 --> 00:15:14,240
to minerals and producing three products

417
00:15:16,629 --> 00:15:15,760
generally and it seems like it should be

418
00:15:18,629 --> 00:15:16,639
rather

419
00:15:21,110 --> 00:15:18,639
a simple thing

420
00:15:22,550 --> 00:15:21,120
but it's really not so simple once you

421
00:15:23,750 --> 00:15:22,560
get into the details and i think that

422
00:15:26,150 --> 00:15:23,760
will be reflected in some of these

423
00:15:28,150 --> 00:15:26,160
experimental results we see today and

424
00:15:30,629 --> 00:15:28,160
part of the complexity comes in

425
00:15:33,509 --> 00:15:30,639
with the fact that when you take iron in

426
00:15:35,189 --> 00:15:33,519
its ferrous form out of these minerals

427
00:15:37,430 --> 00:15:35,199
uh there's a lot of different holes that

428
00:15:38,870 --> 00:15:37,440
that iron can go to in the products and

429
00:15:41,030 --> 00:15:38,880
they can be in different oxidation

430
00:15:44,230 --> 00:15:41,040
states so you can get iron in serpentine

431
00:15:46,790 --> 00:15:44,240
bruising talc magnetite or water y in

432
00:15:49,430 --> 00:15:46,800
different oxidation states and so it can

433
00:15:51,350 --> 00:15:49,440
be a rather complicated process to

434
00:15:53,990 --> 00:15:51,360
figure out unravel

435
00:15:55,590 --> 00:15:54,000
how how that reaction is going to work

436
00:15:58,629 --> 00:15:55,600
and how it's going to be affected by

437
00:16:01,670 --> 00:15:58,639
different environmental conditions

438
00:16:03,749 --> 00:16:01,680

so just as a as a kind of reflection of

439
00:16:05,829 --> 00:16:03,759
of how complicated these things can be

440
00:16:08,310 --> 00:16:05,839
when you go and study them in the in the

441
00:16:11,269 --> 00:16:08,320
laboratory i've shown a plot here from a

442
00:16:12,949 --> 00:16:11,279
recent paper by benjamin malvoy

443
00:16:14,790 --> 00:16:12,959
that shows the rates of reactions that

444
00:16:17,269 --> 00:16:14,800
have been measured uh rates of

445
00:16:19,030 --> 00:16:17,279
serpentization that have been

446
00:16:21,590 --> 00:16:19,040
measured in laboratory experiments and i

447
00:16:23,430 --> 00:16:21,600
note that these top set of plots up here

448
00:16:25,990 --> 00:16:23,440
have a different uh

449
00:16:29,110 --> 00:16:26,000
uh horizontal axis than the ones down

450
00:16:31,670 --> 00:16:29,120
here and these rates fall into two

451
00:16:33,990 --> 00:16:31,680
desperate disparate groups desperate

452
00:16:37,189 --> 00:16:34,000
maybe two different groups

453
00:16:38,790 --> 00:16:37,199
where uh one set of experiments uh

454
00:16:39,910 --> 00:16:38,800
measure reaction rates that are really

455
00:16:42,069 --> 00:16:39,920
slow

456
00:16:45,030 --> 00:16:42,079
and one set of exp and another set of

457
00:16:47,509 --> 00:16:45,040
experiments uh metal reactions rates

458
00:16:49,670 --> 00:16:47,519
that are really fast so if these these

459
00:16:51,350 --> 00:16:49,680
ones in the upper left here these fast

460
00:16:53,509 --> 00:16:51,360
reactions are what is really controlling

461
00:16:55,509 --> 00:16:53,519
rates of reactions in certain natural

462
00:16:57,110 --> 00:16:55,519
circles that would imply on geologic

463
00:16:58,069 --> 00:16:57,120

time scales this is a really fast

464
00:17:00,550 --> 00:16:58,079
process

465
00:17:02,310 --> 00:17:00,560
whereas if these are more representative

466
00:17:04,230 --> 00:17:02,320
the ones in the lower right then

467
00:17:06,069 --> 00:17:04,240
serpentization in geologic systems may

468
00:17:08,549 --> 00:17:06,079
be very slow

469
00:17:10,789 --> 00:17:08,559
and uh there's been a number of studies

470
00:17:12,150 --> 00:17:10,799
published since this came out and again

471
00:17:13,909 --> 00:17:12,160
they fall into these two groups

472
00:17:16,470 --> 00:17:13,919
sometimes it reports really fast

473
00:17:18,789 --> 00:17:16,480
reactions and sometimes we report really

474
00:17:20,309 --> 00:17:18,799
slow reactions and at this point i don't

475
00:17:22,470 --> 00:17:20,319
think we really have a good grasp of

476
00:17:25,510 --> 00:17:22,480
what's controlling whether these rates

477
00:17:28,069 --> 00:17:25,520
in the in the experimental systems are

478
00:17:31,350 --> 00:17:28,079
fast or slow and how that translates

479
00:17:34,710 --> 00:17:31,360
into the natural system

480
00:17:36,630 --> 00:17:34,720
now again as astrobiologists we're uh

481
00:17:38,470 --> 00:17:36,640
really interested in hydrogen generation

482
00:17:40,310 --> 00:17:38,480
and people have been studying uh

483
00:17:43,110 --> 00:17:40,320
serpentinization in the laboratory for

484
00:17:46,310 --> 00:17:43,120
for several decades many decades uh

485
00:17:48,310 --> 00:17:46,320
doing experiments but but uh most of the

486
00:17:51,190 --> 00:17:48,320
older studies were really

487
00:17:52,789 --> 00:17:51,200
uh performed to uh address other

488
00:17:55,430 --> 00:17:52,799

objectives and astrobiologies things

489
00:17:57,590 --> 00:17:55,440
like dehydration of certain serpent

490
00:18:01,110 --> 00:17:57,600
nights in in subduction zones things

491
00:18:02,870 --> 00:18:01,120
like that and as a consequence uh

492
00:18:04,549 --> 00:18:02,880
uh there has been little there was a

493
00:18:06,390 --> 00:18:04,559
little attention to things we're

494
00:18:08,950 --> 00:18:06,400
interested in astrobiologists such as

495
00:18:11,350 --> 00:18:08,960
hydro degeneration so this plot here

496
00:18:13,590 --> 00:18:11,360
just shows uh all the studies that were

497
00:18:15,430 --> 00:18:13,600
available as of 2007 that it had

498
00:18:17,830 --> 00:18:15,440
measured the hydrogen generation during

499
00:18:19,669 --> 00:18:17,840
serpentinization and so this is on the

500
00:18:22,549 --> 00:18:19,679
on the uh on the

501
00:18:25,190 --> 00:18:22,559
y-axis here this is hydrogen generation

502
00:18:27,990 --> 00:18:25,200
in millimoles per gram of fluids versus

503
00:18:31,029 --> 00:18:28,000
elapsed time in hours on the uh

504
00:18:33,190 --> 00:18:31,039
on the x-axis there and you can see that

505
00:18:34,950 --> 00:18:33,200
at that time there were really uh just

506
00:18:36,070 --> 00:18:34,960
very few studies and if you could read

507
00:18:40,150 --> 00:18:36,080
this uh

508
00:18:42,950 --> 00:18:40,160
all these are conducted at temperatures

509
00:18:44,150 --> 00:18:42,960
of 300 and 400 degrees so if you wanted

510
00:18:46,630 --> 00:18:44,160
to know what's going to happen in a

511
00:18:47,830 --> 00:18:46,640
near-surface continental system

512
00:18:49,830 --> 00:18:47,840
those things are not going to give you a

513
00:18:52,549 --> 00:18:49,840

whole lot of information about

514
00:18:54,950 --> 00:18:52,559
what's going on there

515
00:18:57,270 --> 00:18:54,960
so in this next plot i've shown

516
00:18:58,549 --> 00:18:57,280
some more recent results so over the

517
00:18:59,750 --> 00:18:58,559
last decade people have been more

518
00:19:01,590 --> 00:18:59,760
interested in this and starting to

519
00:19:03,270 --> 00:19:01,600
measure hydrogen regeneration rates and

520
00:19:05,669 --> 00:19:03,280
different kinds of systems and the

521
00:19:07,830 --> 00:19:05,679
situation is improving somewhat so you

522
00:19:10,150 --> 00:19:07,840
can see now there's a whole range of

523
00:19:11,990 --> 00:19:10,160
temperatures covered uh different kinds

524
00:19:15,029 --> 00:19:12,000
of substrates that have been used in

525
00:19:18,549 --> 00:19:15,039
these experiments and yet uh there's a

526
00:19:20,070 --> 00:19:18,559
lot of disparity again in these uh

527
00:19:23,029 --> 00:19:20,080
in these data so you can see just like

528
00:19:24,870 --> 00:19:23,039
at a single temperature the hydrogen

529
00:19:27,110 --> 00:19:24,880
generation rate from these experiments

530
00:19:28,549 --> 00:19:27,120
could range over four or more orders of

531
00:19:31,190 --> 00:19:28,559
magnitude

532
00:19:32,710 --> 00:19:31,200
and uh what what is causing that

533
00:19:35,110 --> 00:19:32,720
variation in these different

534
00:19:37,990 --> 00:19:35,120
experimental systems is still under

535
00:19:40,150 --> 00:19:38,000
investigation it's tied up with reaction

536
00:19:42,630 --> 00:19:40,160
rates with where the iron is going but

537
00:19:45,990 --> 00:19:42,640
what really is controlling all that uh

538
00:19:47,510 --> 00:19:46,000

is is still a matter of of debate and

539
00:19:49,830 --> 00:19:47,520
especially down in low temperatures

540
00:19:50,950 --> 00:19:49,840
where we're interested in kind of

541
00:19:54,870 --> 00:19:50,960
uh

542
00:19:56,789 --> 00:19:54,880
we want to know if there's hydrogen

543
00:20:00,070 --> 00:19:56,799
generated at a rate that would be able

544
00:20:02,789 --> 00:20:00,080
to supply these kind of organisms micro

545
00:20:04,390 --> 00:20:02,799
microbial activities uh there's still a

546
00:20:07,510 --> 00:20:04,400
lot to be resolved about how what the

547
00:20:09,110 --> 00:20:07,520
rates are in that kind of environment

548
00:20:10,870 --> 00:20:09,120
tom we have a question from adrian brown

549
00:20:13,190 --> 00:20:10,880
he's asking what does the purple arrow

550
00:20:14,630 --> 00:20:13,200
indicate here oh the sorry the purple

551
00:20:16,470 --> 00:20:14,640
layer indica that's because that's a

552
00:20:18,470 --> 00:20:16,480
maximum value because hydrogen was

553
00:20:20,950 --> 00:20:18,480
actually undetectable

554
00:20:22,870 --> 00:20:20,960
uh in in some of these in some of these

555
00:20:24,549 --> 00:20:22,880
experiments down in this part of the

556
00:20:25,990 --> 00:20:24,559
region uh these the hydrogen

557
00:20:28,149 --> 00:20:26,000
degeneration is so low it's hard to

558
00:20:29,110 --> 00:20:28,159
detect and in this particular experiment

559
00:20:31,510 --> 00:20:29,120
here

560
00:20:32,870 --> 00:20:31,520
uh it could not be detected from bad

561
00:20:34,789 --> 00:20:32,880
differentiated from background so that

562
00:20:36,310 --> 00:20:34,799
would be the maximum rate it's that's

563
00:20:38,950 --> 00:20:36,320

lower and and i should mention these

564
00:20:41,590 --> 00:20:38,960
lines are are my kind of like simplistic

565
00:20:43,669 --> 00:20:41,600
attempt to try and put a uh

566
00:20:45,750 --> 00:20:43,679
apply first order reaction kinetics and

567
00:20:47,590 --> 00:20:45,760
extrapolate from the higher temperatures

568
00:20:49,990 --> 00:20:47,600
down into these lower temperature range

569
00:20:51,990 --> 00:20:50,000
and some of these data seem to

570
00:20:54,230 --> 00:20:52,000
seem to agree with the

571
00:20:56,470 --> 00:20:54,240
these extrapolations

572
00:20:58,549 --> 00:20:56,480
uh and some do not but these are

573
00:21:01,270 --> 00:20:58,559
extrapolations are really not based on

574
00:21:03,270 --> 00:21:01,280
any kind of mechanistic information or

575
00:21:05,350 --> 00:21:03,280
anything like that it's just simply

576
00:21:07,270 --> 00:21:05,360
applying first order arrhenius

577
00:21:08,950 --> 00:21:07,280
parameters and and

578
00:21:10,870 --> 00:21:08,960
doing a a

579
00:21:14,549 --> 00:21:10,880
calculation with that so i i don't know

580
00:21:17,110 --> 00:21:14,559
whether those are realistic or not

581
00:21:20,549 --> 00:21:17,120
so uh getting into the modeling side

582
00:21:22,870 --> 00:21:20,559
something that has been uh done uh

583
00:21:24,710 --> 00:21:22,880
with the information that's available

584
00:21:26,630 --> 00:21:24,720
out there on the chemical composition of

585
00:21:28,950 --> 00:21:26,640
these uh kind of

586
00:21:31,669 --> 00:21:28,960
serpentinizing fluids is to

587
00:21:33,750 --> 00:21:31,679
make a determination of the uh amount of

588
00:21:36,630 --> 00:21:33,760

chemical energy that's available to sort

589
00:21:38,310 --> 00:21:36,640
micro organisms uh just taking kind of a

590
00:21:40,070 --> 00:21:38,320
snapshot

591
00:21:41,990 --> 00:21:40,080
approach to that

592
00:21:44,630 --> 00:21:42,000
and we saw some similar kinds of

593
00:21:47,830 --> 00:21:44,640
calculations done yesterday

594
00:21:51,029 --> 00:21:47,840
uh presented by uh everett chalk from uh

595
00:21:52,710 --> 00:21:51,039
peter canovis's work uh this is a plot

596
00:21:55,750 --> 00:21:52,720
uh just shows some similar kinds of

597
00:21:57,430 --> 00:21:55,760
calculations done by by jana mend

598
00:21:59,909 --> 00:21:57,440
published a few years back looking at

599
00:22:01,590 --> 00:21:59,919
the amount of energy available in in

600
00:22:04,789 --> 00:22:01,600
some uh

601
00:22:07,350 --> 00:22:04,799
ultramafic hosted uh uh seafloor systems

602
00:22:09,590 --> 00:22:07,360
but this is something that you can

603
00:22:10,789 --> 00:22:09,600
an exercise you can do uh it's kind of

604
00:22:12,710 --> 00:22:10,799
modeled it kind of plays some

605
00:22:14,630 --> 00:22:12,720
constraints on what should be going on

606
00:22:16,390 --> 00:22:14,640
there microbiologically

607
00:22:18,630 --> 00:22:16,400
and link the chemistry

608
00:22:20,149 --> 00:22:18,640
uh with the biology and i think we'll

609
00:22:22,070 --> 00:22:20,159
see this morning

610
00:22:24,630 --> 00:22:22,080
sanjoy psalm taking this kind of

611
00:22:26,710 --> 00:22:24,640
approach a step further

612
00:22:28,950 --> 00:22:26,720
to explore uh kind of the dimension

613
00:22:30,950 --> 00:22:28,960

space of of uh

614
00:22:33,590 --> 00:22:30,960
metabolic energy availability in these

615
00:22:38,470 --> 00:22:36,149
so uh just uh to mention the last thing

616
00:22:40,470 --> 00:22:38,480
that uh here that

617
00:22:43,350 --> 00:22:40,480
uh astrobiologists are interested in

618
00:22:46,070 --> 00:22:43,360
serpentization systems is because uh

619
00:22:47,590 --> 00:22:46,080
there are a lot of reasons to think that

620
00:22:50,390 --> 00:22:47,600
maybe these kind of systems could have

621
00:22:52,470 --> 00:22:50,400
been the locations where the first uh

622
00:22:55,190 --> 00:22:52,480
metabolic process emerged from where the

623
00:22:57,029 --> 00:22:55,200
original life maybe got its start

624
00:22:59,430 --> 00:22:57,039
uh and so we're gonna hear some more

625
00:23:01,990 --> 00:22:59,440
about that uh later on this morning from

626
00:23:04,149 --> 00:23:02,000
or later on today from mike russell

627
00:23:05,830 --> 00:23:04,159
so uh these systems that we're looking

628
00:23:08,549 --> 00:23:05,840
at today could potentially be a window

629
00:23:09,750 --> 00:23:08,559
into the origin of life both on earth

630
00:23:12,310 --> 00:23:09,760
and on other

631
00:23:14,230 --> 00:23:12,320
astrobiology targets

632
00:23:17,029 --> 00:23:14,240
and uh that's pretty much all i have to

633
00:23:18,390 --> 00:23:17,039
say for in terms of introduction

634
00:23:19,990 --> 00:23:18,400
and uh

635
00:23:22,789 --> 00:23:20,000
if there are any questions or anything

636
00:23:25,669 --> 00:23:22,799
that anybody uh had to bring up

637
00:23:29,270 --> 00:23:25,679
uh had questions about that

638
00:23:31,190 --> 00:23:29,280

uh if not then uh we will bring on our

639
00:23:33,190 --> 00:23:31,200
first speaker who is frieder kline from

640
00:23:37,029 --> 00:23:33,200
woods hole oceanographic institution if

641
00:23:39,909 --> 00:23:37,039
he's there frieda are you hello can you

642
00:23:41,750 --> 00:23:39,919
hear me hello i can hear you

643
00:23:43,830 --> 00:23:41,760
you can hear me morning for you

644
00:23:46,390 --> 00:23:43,840
good morning hello

645
00:23:48,230 --> 00:23:46,400
and good afternoon to everyone else

646
00:23:49,990 --> 00:23:48,240
yeah i forgot to mention that he has a

647
00:23:52,310 --> 00:23:50,000
good afternoon or evening or whatever

648
00:23:54,630 --> 00:23:52,320
whatever your time zone happens to

649
00:23:55,909 --> 00:23:54,640
so freighter this is uh mike twyone um i

650
00:23:57,909 --> 00:23:55,919
brought your slides up if you want to

651
00:23:59,669 --> 00:23:57,919
start your webcam that would be great it

652
00:24:01,340 --> 00:23:59,679
should be right the button right above

653
00:24:04,549 --> 00:24:01,350
tom's head

654
00:24:10,470 --> 00:24:06,230
perfect

655
00:24:16,950 --> 00:24:12,630
i'm not nearly as handsome on the on the

656
00:24:22,230 --> 00:24:19,430
the treater is oh wow yeah

657
00:24:23,990 --> 00:24:22,240
i'm all dressed up

658
00:24:25,750 --> 00:24:24,000
all right peter it's in your it's in

659
00:24:28,390 --> 00:24:25,760
your capable hands

660
00:24:30,149 --> 00:24:28,400
all right well thank you so much uh

661
00:24:33,029 --> 00:24:30,159
before i start i would like to thank the

662
00:24:36,149 --> 00:24:33,039
workshop organizers and also acknowledge

663
00:24:39,669 --> 00:24:36,159

the contributions of my colleagues

664
00:24:40,950 --> 00:24:39,679
and some support from hui nsf and and

665
00:24:43,669 --> 00:24:40,960
iotp

666
00:24:45,990 --> 00:24:43,679
so olivine rich rocks are unstable in

667
00:24:47,990 --> 00:24:46,000
the presence of water and

668
00:24:50,710 --> 00:24:48,000
at temperatures of about 400 degrees c

669
00:24:52,789 --> 00:24:50,720
and below and undergo a series of

670
00:24:55,510 --> 00:24:52,799
dissolution precipitation and redux

671
00:24:57,350 --> 00:24:55,520
reactions to form the pantonite a rock

672
00:24:59,750 --> 00:24:57,360
that is mainly composed of the mineral

673
00:25:02,310 --> 00:24:59,760
serpentine as we've heard just now

674
00:25:04,470 --> 00:25:02,320
so this process which we refer to as the

675
00:25:06,870 --> 00:25:04,480
pentatonization creates geochemical

676
00:25:09,029 --> 00:25:06,880
conditions and hydrogen

677
00:25:10,710 --> 00:25:09,039
that make the lost city

678
00:25:12,710 --> 00:25:10,720
hydrothermal system that is pictured

679
00:25:15,669 --> 00:25:12,720
here so remarkable

680
00:25:20,950 --> 00:25:17,590
okay

681
00:25:22,630 --> 00:25:20,960
trying to click on the next

682
00:25:25,350 --> 00:25:22,640
slide here

683
00:25:26,870 --> 00:25:25,360
so uh freda if you click on the uh icon

684
00:25:28,470 --> 00:25:26,880
in the lower left of your slides there's

685
00:25:30,470 --> 00:25:28,480
a left arrow and a right arrow clicking

686
00:25:32,909 --> 00:25:30,480
on the right arrow advance

687
00:25:35,669 --> 00:25:32,919
got it all right cool so uh

688
00:25:38,549 --> 00:25:35,679

sepentenization occurs at slow and ultra

689
00:25:41,590 --> 00:25:38,559
flow spreading ridges um at oceanic core

690
00:25:43,110 --> 00:25:41,600
complexes in fracture zones and then

691
00:25:44,149 --> 00:25:43,120
tectonic windows

692
00:25:48,710 --> 00:25:44,159
at

693
00:25:50,630 --> 00:25:48,720
margins and in forex settings of

694
00:25:53,350 --> 00:25:50,640
subduction zones

695
00:25:56,149 --> 00:25:53,360
and this map which we some of you have

696
00:25:57,909 --> 00:25:56,159
seen yesterday during a matt's talk

697
00:26:00,950 --> 00:25:57,919
shows the occurrence of the pantonites

698
00:26:03,669 --> 00:26:00,960
on land so they they occur in archaean

699
00:26:05,510 --> 00:26:03,679
and proterozoic green stone belts and in

700
00:26:07,750 --> 00:26:05,520
phanerozoic mountain ranges and

701
00:26:10,230 --> 00:26:07,760
ophiolites and in some of these settings

702
00:26:12,470 --> 00:26:10,240
systemization is ongoing demonstrating

703
00:26:14,070 --> 00:26:12,480
that the pentamization is a process that

704
00:26:17,350 --> 00:26:14,080
has been active throughout most of

705
00:26:19,990 --> 00:26:17,360
earth's geologic history

706
00:26:22,230 --> 00:26:20,000
and so pentenization affects geophysical

707
00:26:25,430 --> 00:26:22,240
properties of prototype it decreases the

708
00:26:27,909 --> 00:26:25,440
density the seismic velocity the shear

709
00:26:29,990 --> 00:26:27,919
strength which can be all

710
00:26:32,310 --> 00:26:30,000
nicely shown in the simple box diagram

711
00:26:36,470 --> 00:26:34,070
and it increases the magnetic

712
00:26:39,350 --> 00:26:36,480
susceptibility of the affected rocks

713
00:26:41,510 --> 00:26:39,360

which you can see on the seafloor

714
00:26:43,669 --> 00:26:41,520
so the pentanite hosted hydrothermal

715
00:26:46,070 --> 00:26:43,679
systems like lost city or logachef on

716
00:26:47,909 --> 00:26:46,080
the mid-atlantic ridge then fluids that

717
00:26:50,710 --> 00:26:47,919
are strongly enriched in hydrogen and

718
00:26:52,710 --> 00:26:50,720
methane and poor in h2s and silica

719
00:26:55,350 --> 00:26:52,720
relative to tag which is

720
00:26:57,510 --> 00:26:55,360
the salt hosted hydrothermal system

721
00:26:59,510 --> 00:26:57,520
the ph of serpentinization fluids can

722
00:27:02,149 --> 00:26:59,520
range from acidic at high temperatures

723
00:27:03,909 --> 00:27:02,159
to alkaline at low temperatures and to

724
00:27:05,909 --> 00:27:03,919
date the controls on the fluid

725
00:27:08,310 --> 00:27:05,919
composition during separation are not

726
00:27:10,230 --> 00:27:08,320
completely understood

727
00:27:12,230 --> 00:27:10,240
the hydrogen generation

728
00:27:15,430 --> 00:27:12,240
generated during separatisation can

729
00:27:18,230 --> 00:27:15,440
reduce the oxidized carbon to methane

730
00:27:21,029 --> 00:27:18,240
and of time if time allows as

731
00:27:23,110 --> 00:27:21,039
susan has pointed out yesterday and can

732
00:27:23,909 --> 00:27:23,120
also form other hydrocarbons

733
00:27:26,789 --> 00:27:23,919
and the

734
00:27:28,310 --> 00:27:26,799
reduced volatiles can support microbial

735
00:27:30,070 --> 00:27:28,320
activity

736
00:27:33,590 --> 00:27:30,080
particularly in areas where hydrothermal

737
00:27:35,909 --> 00:27:33,600
fluids mix with seawater

738
00:27:38,950 --> 00:27:35,919

and um here's an example from the

739
00:27:40,789 --> 00:27:38,960
cretaceous iberia margin where we found

740
00:27:42,950 --> 00:27:40,799
the fossil remains of microbial

741
00:27:45,590 --> 00:27:42,960
communities and the pentagonites were

742
00:27:48,070 --> 00:27:45,600
covered by the ocean dwelling program

743
00:27:50,630 --> 00:27:48,080
the microbes here are trapped in brucite

744
00:27:52,950 --> 00:27:50,640
calcite veins that formed at about 65

745
00:27:55,190 --> 00:27:52,960
meters below the seafloor by mixing

746
00:27:57,029 --> 00:27:55,200
between arctic seawater and reduced

747
00:27:59,510 --> 00:27:57,039
hydrothermal fluid

748
00:28:01,990 --> 00:27:59,520
the the biomarkers that we extracted and

749
00:28:03,909 --> 00:28:02,000
also measured in situ suggest that these

750
00:28:06,549 --> 00:28:03,919
organisms were likely similar to those

751
00:28:08,549 --> 00:28:06,559
that lost city

752
00:28:10,230 --> 00:28:08,559
exploiting chemical gradients to gain

753
00:28:12,230 --> 00:28:10,240
metabolic energy

754
00:28:14,149 --> 00:28:12,240
so it turns out that the pentatonization

755
00:28:16,230 --> 00:28:14,159
does not only support microbes and

756
00:28:17,430 --> 00:28:16,240
surface environments it also does that

757
00:28:19,909 --> 00:28:17,440
in

758
00:28:22,549 --> 00:28:19,919
the subsurface too

759
00:28:24,149 --> 00:28:22,559
so hypothesis put forth by mike russell

760
00:28:25,750 --> 00:28:24,159
and others and i'm sure we'll hear more

761
00:28:28,230 --> 00:28:25,760
about that later suggests that the

762
00:28:30,870 --> 00:28:28,240
pentagon hosted alkaline hydrothermal

763
00:28:33,750 --> 00:28:30,880

systems were possible or likely venues

764
00:28:35,510 --> 00:28:33,760
for the origin of life on earth

765
00:28:37,750 --> 00:28:35,520
and an

766
00:28:39,909 --> 00:28:37,760
analogy to earth the pentnite hosted

767
00:28:42,710 --> 00:28:39,919
life may also exist on icy moons and

768
00:28:44,950 --> 00:28:42,720
other waterwearing planetary bodies in

769
00:28:47,029 --> 00:28:44,960
our solar system and maybe beyond

770
00:28:49,350 --> 00:28:47,039
so taken together as a patternization is

771
00:28:51,669 --> 00:28:49,360
a widespread ancient yet still active

772
00:28:53,430 --> 00:28:51,679
process with numerous implications for

773
00:28:54,870 --> 00:28:53,440
chemical physical and biological

774
00:28:56,950 --> 00:28:54,880
processes

775
00:28:58,549 --> 00:28:56,960
yet our understanding of the underlying

776
00:29:00,710 --> 00:28:58,559
fluid rock interactions during the

777
00:29:03,269 --> 00:29:00,720
pentamization is pretty limited

778
00:29:05,510 --> 00:29:03,279
so in the remaining time i would

779
00:29:07,350 --> 00:29:05,520
introduce you to some basic petrological

780
00:29:09,830 --> 00:29:07,360
concepts and some new results

781
00:29:11,350 --> 00:29:09,840
particularly on iron distribution during

782
00:29:14,149 --> 00:29:11,360
serpentinization

783
00:29:16,870 --> 00:29:14,159
the hydrogen generation and um you know

784
00:29:18,710 --> 00:29:16,880
the the the variant various pathways of

785
00:29:20,630 --> 00:29:18,720
pentatonization

786
00:29:22,789 --> 00:29:20,640
so we've seen similar slides before

787
00:29:24,230 --> 00:29:22,799
actually mainly then you've seen uh the

788
00:29:25,909 --> 00:29:24,240

same as the penta knight over and over

789
00:29:28,789 --> 00:29:25,919
again so i thought i would show a

790
00:29:30,710 --> 00:29:28,799
different uh pentonite here for a change

791
00:29:33,029 --> 00:29:30,720
uh so pentanite is the process that

792
00:29:35,269 --> 00:29:33,039
describes the reaction between

793
00:29:37,190 --> 00:29:35,279
a rock which in olivine and pyroxene

794
00:29:39,110 --> 00:29:37,200
typically breed aside

795
00:29:41,190 --> 00:29:39,120
with water to form another rock that we

796
00:29:43,269 --> 00:29:41,200
call pentanite which is

797
00:29:44,870 --> 00:29:43,279
mainly composed of serpentine in

798
00:29:48,870 --> 00:29:44,880
addition to a number of other hydrous

799
00:29:50,789 --> 00:29:48,880
minerals oxides sulfides and alloys so

800
00:29:52,630 --> 00:29:50,799
in a nutshell it's a sequence of

801
00:29:54,389 --> 00:29:52,640
dissolution precipitation and redox

802
00:29:56,870 --> 00:29:54,399
reactions

803
00:29:57,830 --> 00:29:56,880
and hydrogen forms is a byproduct of

804
00:30:00,470 --> 00:29:57,840
this

805
00:30:02,710 --> 00:30:00,480
these reaction sequences

806
00:30:05,350 --> 00:30:02,720
so the major reactions can be depicted

807
00:30:07,029 --> 00:30:05,360
in the simplified diagram a ternary

808
00:30:09,430 --> 00:30:07,039
camograph that

809
00:30:11,669 --> 00:30:09,440
depicts the compositions of the two

810
00:30:15,269 --> 00:30:11,679
primary minerals that refer before

811
00:30:17,669 --> 00:30:15,279
olivine in pyroxene uh he represented by

812
00:30:20,389 --> 00:30:17,679
the magnesium end members four straight

813
00:30:24,149 --> 00:30:20,399

and ensite and the three main secondary

814
00:30:29,430 --> 00:30:27,830
rootside serpentine and tuck so if we

815
00:30:32,230 --> 00:30:29,440
start

816
00:30:34,470 --> 00:30:33,669
olivine here

817
00:30:38,789 --> 00:30:34,480
and

818
00:30:42,149 --> 00:30:38,799
add water we walk across the h2o

819
00:30:44,870 --> 00:30:42,159
towards the atro apex and cross the

820
00:30:48,230 --> 00:30:44,880
timeline of bruceite and serpentine so

821
00:30:50,549 --> 00:30:48,240
that's what we make in in reaction 1.

822
00:30:52,870 --> 00:30:50,559
we can we can play the same

823
00:30:55,830 --> 00:30:52,880
game for pyroxene so we start with

824
00:30:59,110 --> 00:30:55,840
pyroxene add water and cross the tie

825
00:31:01,110 --> 00:30:59,120
line um between serpentine and talc and

826
00:31:04,149 --> 00:31:01,120
that's what's illustrated in

827
00:31:06,950 --> 00:31:04,159
reaction two so only if the right

828
00:31:09,830 --> 00:31:06,960
amounts of olivine and pyroxene are

829
00:31:12,310 --> 00:31:09,840
reacting we add water

830
00:31:13,990 --> 00:31:12,320
we will end up with serpentine only

831
00:31:16,789 --> 00:31:14,000
if we want to make

832
00:31:19,350 --> 00:31:16,799
talc we have to either remove magnesium

833
00:31:21,269 --> 00:31:19,360
or add silica to

834
00:31:23,190 --> 00:31:21,279
to the system

835
00:31:25,110 --> 00:31:23,200
so

836
00:31:28,630 --> 00:31:25,120
in order to understand the formation of

837
00:31:29,669 --> 00:31:28,640
hydrogen however we have to consider

838
00:31:32,230 --> 00:31:29,679

the

839
00:31:34,070 --> 00:31:32,240
distribution and oxidation state of iron

840
00:31:36,950 --> 00:31:34,080
and secondary minerals and thomas shown

841
00:31:38,549 --> 00:31:36,960
this image before it shows an unhappy

842
00:31:39,669 --> 00:31:38,559
olivine

843
00:31:40,470 --> 00:31:39,679
that

844
00:31:46,549 --> 00:31:40,480
is

845
00:31:50,149 --> 00:31:46,559
the the fuzzy stuff here

846
00:31:52,549 --> 00:31:50,159
and uh brucite the tabular mineral and

847
00:31:53,990 --> 00:31:52,559
the the octahedral magnetite all of

848
00:31:57,830 --> 00:31:54,000
these minerals

849
00:31:59,909 --> 00:31:57,840
contain considerable amount of iron and

850
00:32:01,990 --> 00:31:59,919
to make hydrogen we need to oxidize the

851
00:32:04,870 --> 00:32:02,000
iron originally contained in olivine to

852
00:32:08,549 --> 00:32:04,880
ferric iron and magnetite

853
00:32:09,750 --> 00:32:08,559
as shown in the uppermost equation here

854
00:32:11,990 --> 00:32:09,760
or

855
00:32:13,750 --> 00:32:12,000
to ferric iron and serpentine shown

856
00:32:16,310 --> 00:32:13,760
shown in this reaction

857
00:32:18,230 --> 00:32:16,320
so however not all of the iron

858
00:32:20,470 --> 00:32:18,240
that is incorporated in secondary

859
00:32:22,710 --> 00:32:20,480
minerals here blue side is being

860
00:32:25,509 --> 00:32:22,720
oxidized and on

861
00:32:29,509 --> 00:32:25,519
the example for serpentine and so that

862
00:32:31,269 --> 00:32:29,519
however limits the hydrogen generation

863
00:32:33,590 --> 00:32:31,279

potential

864
00:32:36,149 --> 00:32:33,600
so this diagram which is admittedly a

865
00:32:38,230 --> 00:32:36,159
little convoluted illustrates the the

866
00:32:40,630 --> 00:32:38,240
density magnetic susceptibility

867
00:32:43,430 --> 00:32:40,640
relationship of partially to fully

868
00:32:45,909 --> 00:32:43,440
sepanized rock and i'll very briefly

869
00:32:49,269 --> 00:32:45,919
walk you through it so we start out with

870
00:32:52,950 --> 00:32:49,279
an unaltered peridotite

871
00:32:56,149 --> 00:32:52,960
um in the lower right corner here and

872
00:32:59,029 --> 00:32:56,159
the that is a dense and weakly magnetic

873
00:33:01,029 --> 00:32:59,039
rock and as the peptidation progresses

874
00:33:04,230 --> 00:33:01,039
serpentine forms which

875
00:33:06,149 --> 00:33:04,240
is less dense and so we move to the left

876
00:33:08,470 --> 00:33:06,159
and um

877
00:33:11,509 --> 00:33:08,480
if magnetite forms the magnetic

878
00:33:13,430 --> 00:33:11,519
susceptibility increases and we move up

879
00:33:16,389 --> 00:33:13,440
right so however in some periodic types

880
00:33:19,750 --> 00:33:16,399
that are completely sepantonized um we

881
00:33:22,149 --> 00:33:19,760
we don't see uh elevated um magnetic

882
00:33:24,389 --> 00:33:22,159
acceptability right as shown here in the

883
00:33:26,230 --> 00:33:24,399
lower left corner room arrows and it

884
00:33:28,470 --> 00:33:26,240
turns out that separatisation is a

885
00:33:30,950 --> 00:33:28,480
process that can follow different and

886
00:33:34,630 --> 00:33:30,960
quite complex pathways and the key

887
00:33:36,549 --> 00:33:34,640
questions that i want to address is

888
00:33:38,870 --> 00:33:36,559

what are these different pathways and

889
00:33:41,029 --> 00:33:38,880
what controls the reaction pathways of

890
00:33:42,310 --> 00:33:41,039
subpoenaization or in other words what

891
00:33:44,710 --> 00:33:42,320
determines

892
00:33:46,630 --> 00:33:44,720
which of the many possible

893
00:33:48,710 --> 00:33:46,640
dissolution precipitation and redux

894
00:33:51,590 --> 00:33:48,720
reactions that take place

895
00:33:52,950 --> 00:33:51,600
occur when do they take place and and

896
00:33:55,909 --> 00:33:52,960
why is that

897
00:33:58,630 --> 00:33:55,919
so um to to address this

898
00:34:00,630 --> 00:33:58,640
our approach has to be or is to

899
00:34:03,909 --> 00:34:00,640
integrate the results from field

900
00:34:07,110 --> 00:34:03,919
observations laboratory experiments and

901
00:34:08,790 --> 00:34:07,120
theoretical constraints so thermodynamic

902
00:34:10,550 --> 00:34:08,800
reaction path modeling

903
00:34:11,829 --> 00:34:10,560
equilibrium modeling is particularly

904
00:34:14,069 --> 00:34:11,839
efficient

905
00:34:16,550 --> 00:34:14,079
way to examine some aspects of the

906
00:34:18,149 --> 00:34:16,560
pentatonization and without going into

907
00:34:20,869 --> 00:34:18,159
the details here the beauty of

908
00:34:23,109 --> 00:34:20,879
thermodynamic modeling is that

909
00:34:24,950 --> 00:34:23,119
the composition of fluids minerals and

910
00:34:27,030 --> 00:34:24,960
rocks can be predicted as a function of

911
00:34:30,550 --> 00:34:27,040
for example temperature pressure and

912
00:34:35,270 --> 00:34:33,510
so the way this works for temperature as

913
00:34:37,589 --> 00:34:35,280

a key variable for example is

914
00:34:39,270 --> 00:34:37,599
illustrated in this simple cartoon

915
00:34:43,430 --> 00:34:39,280
we

916
00:34:45,990 --> 00:34:43,440
distribution of seawater

917
00:34:48,470 --> 00:34:46,000
then we add a solid

918
00:34:50,470 --> 00:34:48,480
reactant and equilibrate the system

919
00:34:52,710 --> 00:34:50,480
and then we change the temperature and

920
00:34:54,550 --> 00:34:52,720
see how the mineralogy mineral and fluid

921
00:34:56,149 --> 00:34:54,560
composition changes as a function of

922
00:34:57,109 --> 00:34:56,159
temperature

923
00:34:59,030 --> 00:34:57,119
so

924
00:35:00,870 --> 00:34:59,040
in this slide here and the upper

925
00:35:03,670 --> 00:35:00,880
diagrams show the predicted mineral

926
00:35:06,310 --> 00:35:03,680
assemblage for serpentinization of

927
00:35:08,630 --> 00:35:06,320
olivine here on the left and

928
00:35:10,470 --> 00:35:08,640
orthopyroxene on the right

929
00:35:13,589 --> 00:35:10,480
as a function of temperature

930
00:35:16,950 --> 00:35:13,599
and olivine is unstable

931
00:35:19,190 --> 00:35:16,960
at temperatures below about 320 degrees

932
00:35:21,190 --> 00:35:19,200
c and is replaced by serpentine blue

933
00:35:24,150 --> 00:35:21,200
side and magnetite

934
00:35:26,310 --> 00:35:24,160
so magnetizes this yellow field here

935
00:35:28,550 --> 00:35:26,320
magnetite is predicted to be stable only

936
00:35:30,870 --> 00:35:28,560
at temperatures higher than about 200

937
00:35:32,870 --> 00:35:30,880
degrees c during the penaltization of

938
00:35:35,750 --> 00:35:32,880

volume to use the potentialization of

939
00:35:36,870 --> 00:35:35,760
aquaporix which is unstable

940
00:35:38,870 --> 00:35:36,880
in

941
00:35:40,550 --> 00:35:38,880
this temperature range here

942
00:35:42,790 --> 00:35:40,560
serpentine and talc are the main

943
00:35:44,950 --> 00:35:42,800
alteration products and magnetite does

944
00:35:48,230 --> 00:35:44,960
not form at all so during the

945
00:35:49,670 --> 00:35:48,240
feminization of olivine uh magnetized is

946
00:35:51,829 --> 00:35:49,680
not part of the predicted mineral

947
00:35:55,109 --> 00:35:51,839
assemblage at low temperatures

948
00:35:56,390 --> 00:35:55,119
because brewside is taking up a lot of

949
00:35:58,710 --> 00:35:56,400
iron

950
00:36:00,310 --> 00:35:58,720
and does uh so increasingly with

951
00:36:02,470 --> 00:36:00,320
decreasing temperature

952
00:36:05,430 --> 00:36:02,480
so for comparison

953
00:36:08,390 --> 00:36:05,440
uh serpentinization of orthopyroxene

954
00:36:11,430 --> 00:36:08,400
does not produce magnetite because the

955
00:36:12,710 --> 00:36:11,440
iron content um or the increased silica

956
00:36:15,190 --> 00:36:12,720
activities

957
00:36:17,589 --> 00:36:15,200
allow serpentine to contain a lot more

958
00:36:20,470 --> 00:36:17,599
iron which leaves less room or less

959
00:36:23,589 --> 00:36:20,480
affinity to form magnetite

960
00:36:26,310 --> 00:36:23,599
so now let's expand this model to cpx or

961
00:36:28,790 --> 00:36:26,320
clinoproxy bearing a peridotite shown

962
00:36:31,190 --> 00:36:28,800
here on the left and peroxide on the

963
00:36:33,670 --> 00:36:31,200

right so the pentatonization of

964
00:36:35,270 --> 00:36:33,680
cpx bearing peridotite so a heartburger

965
00:36:38,790 --> 00:36:35,280
in this case here

966
00:36:41,349 --> 00:36:38,800
stabilizes cpx brucite serpentine and

967
00:36:44,470 --> 00:36:41,359
magnetite whereas the pentatonization of

968
00:36:46,790 --> 00:36:44,480
peroxinite stabilizes torque tremolite

969
00:36:48,550 --> 00:36:46,800
serpentine and chloride the difference

970
00:36:50,950 --> 00:36:48,560
here is quite important actually for our

971
00:36:54,069 --> 00:36:50,960
understanding of serpentinization fluids

972
00:36:56,870 --> 00:36:54,079
as these mineral sandwiches represent

973
00:36:58,710 --> 00:36:56,880
strong buffers in terms of ph

974
00:37:00,069 --> 00:36:58,720
and silica

975
00:37:02,790 --> 00:37:00,079
so

976
00:37:04,390 --> 00:37:02,800
serpentinization of prototype buffers

977
00:37:08,630 --> 00:37:04,400
the ph

978
00:37:13,670 --> 00:37:08,640
of the fluids to much higher values

979
00:37:17,109 --> 00:37:13,680
and and silica to to much lower values

980
00:37:19,510 --> 00:37:17,119
than uh surpatization of peroxide so

981
00:37:22,150 --> 00:37:19,520
um that is that is quite important for

982
00:37:24,630 --> 00:37:22,160
our understanding of the influence of

983
00:37:26,230 --> 00:37:24,640
the protolous composition on the the

984
00:37:28,870 --> 00:37:26,240
fluid chemistry

985
00:37:30,870 --> 00:37:28,880
so this next diagram illustrates the

986
00:37:33,829 --> 00:37:30,880
predicted hydrogen concentration for the

987
00:37:36,870 --> 00:37:33,839
pentatonization of olivine and prototype

988
00:37:39,030 --> 00:37:36,880

as a function of temperature

989
00:37:42,630 --> 00:37:39,040
hydrogen concentrations are highest

990
00:37:47,670 --> 00:37:45,589
at low water truck mass ratios

991
00:37:49,670 --> 00:37:47,680
for comparison also shown measured

992
00:37:51,750 --> 00:37:49,680
hydrogen concentrations and vent fluids

993
00:37:53,510 --> 00:37:51,760
from fifa hydrothermal systems here

994
00:37:55,349 --> 00:37:53,520
larger chef rainbow

995
00:37:56,790 --> 00:37:55,359
and lost city

996
00:37:59,510 --> 00:37:56,800
and

997
00:38:02,950 --> 00:37:59,520
while the predictions here seem to match

998
00:38:04,710 --> 00:38:02,960
the the measured values quite well it is

999
00:38:06,790 --> 00:38:04,720
important to realize that changing the

1000
00:38:09,109 --> 00:38:06,800
watershed rock ratio in the model allows

1001
00:38:11,589 --> 00:38:09,119
us to match any measured composition

1002
00:38:14,150 --> 00:38:11,599
that means there is no unique solution

1003
00:38:16,230 --> 00:38:14,160
from the modeling perspective

1004
00:38:18,150 --> 00:38:16,240
so in the next few slides i'll be

1005
00:38:19,430 --> 00:38:18,160
testing some of the predictions from the

1006
00:38:21,430 --> 00:38:19,440
modeling

1007
00:38:23,430 --> 00:38:21,440
in real rocks recovered by the ocean

1008
00:38:25,750 --> 00:38:23,440
drilling program in a range of different

1009
00:38:27,109 --> 00:38:25,760
geological settings here indicated by

1010
00:38:28,630 --> 00:38:27,119
the numbered circle so at the

1011
00:38:31,750 --> 00:38:28,640
mid-atlantic ridge

1012
00:38:34,150 --> 00:38:31,760
at half deep um iberian margin thurini

1013
00:38:36,310 --> 00:38:34,160

and c and uh mariana four i can i'll do

1014
00:38:38,390 --> 00:38:36,320
that really briefly

1015
00:38:40,069 --> 00:38:38,400
um so

1016
00:38:43,109 --> 00:38:40,079
shown here are two backscattered

1017
00:38:45,430 --> 00:38:43,119
electron images illustrating a magnetite

1018
00:38:47,190 --> 00:38:45,440
um which the pentanonide

1019
00:38:49,190 --> 00:38:47,200
on the left from the mid-atlantic ridge

1020
00:38:50,790 --> 00:38:49,200
that's the mid-atlantic ridge cane

1021
00:38:53,349 --> 00:38:50,800
fracture zone area

1022
00:38:55,030 --> 00:38:53,359
and a magnetite pours the pentanoid from

1023
00:38:55,990 --> 00:38:55,040
the iberia margin

1024
00:38:57,990 --> 00:38:56,000
and

1025
00:39:00,710 --> 00:38:58,000
while the one on the right does not have

1026
00:39:02,550 --> 00:39:00,720
any magnetite it does contain native

1027
00:39:05,589 --> 00:39:02,560
nickel iron which is indicative of

1028
00:39:08,230 --> 00:39:05,599
strong reducing conditions so

1029
00:39:11,190 --> 00:39:08,240
even in the absence of magnetite you can

1030
00:39:14,870 --> 00:39:11,200
create strongly reducing conditions

1031
00:39:17,349 --> 00:39:14,880
and without going into detail uh here so

1032
00:39:21,510 --> 00:39:17,359
conces consistent with our predictions

1033
00:39:25,829 --> 00:39:21,520
um the the magnetite poor the pentanide

1034
00:39:28,470 --> 00:39:25,839
have actually um iron rich uh brucite

1035
00:39:33,190 --> 00:39:28,480
and the magnetite rich the pantonite

1036
00:39:35,510 --> 00:39:33,200
have roosied iron poor blue side of that

1037
00:39:37,750 --> 00:39:35,520
and so

1038
00:39:41,030 --> 00:39:37,760

so that is consistent with a with a

1039
00:39:42,550 --> 00:39:41,040
model but we would like to

1040
00:39:44,470 --> 00:39:42,560
know whether

1041
00:39:46,790 --> 00:39:44,480
whether

1042
00:39:48,550 --> 00:39:46,800
these magnetite rich the pentamites that

1043
00:39:51,109 --> 00:39:48,560
have iron poor bruce are indeed formed

1044
00:39:52,310 --> 00:39:51,119
at hot higher temperatures and vice

1045
00:39:53,510 --> 00:39:52,320
versa

1046
00:39:58,310 --> 00:39:53,520
so

1047
00:40:00,069 --> 00:39:58,320
thermometry and this is a histogram

1048
00:40:03,670 --> 00:40:00,079
shown for

1049
00:40:05,910 --> 00:40:03,680
serpentine seawater oxygen isotopes

1050
00:40:07,750 --> 00:40:05,920
from a range of different

1051
00:40:10,630 --> 00:40:07,760
drill cores

1052
00:40:12,630 --> 00:40:10,640
so what you can see is a bimodal

1053
00:40:13,430 --> 00:40:12,640
distribution

1054
00:40:15,750 --> 00:40:13,440
with

1055
00:40:18,630 --> 00:40:15,760
the ones from the

1056
00:40:21,430 --> 00:40:18,640
mid-ocean ridge setting forming at high

1057
00:40:22,829 --> 00:40:21,440
much higher temperatures than the ones

1058
00:40:26,870 --> 00:40:22,839
that

1059
00:40:30,470 --> 00:40:26,880
um uh form at the ibira margin where

1060
00:40:33,349 --> 00:40:30,480
temperatures are much lower and uh where

1061
00:40:36,870 --> 00:40:33,359
indeed the the magnetite

1062
00:40:39,109 --> 00:40:36,880
is absent and the iron iron

1063
00:40:40,470 --> 00:40:39,119

well the blue side is iron poor

1064
00:40:42,870 --> 00:40:40,480
so

1065
00:40:44,790 --> 00:40:42,880
we can we can gather a lot of

1066
00:40:46,150 --> 00:40:44,800
information from the rock record so we

1067
00:40:48,790 --> 00:40:46,160
can estimate

1068
00:40:50,790 --> 00:40:48,800
what temperature they formed um how much

1069
00:40:51,670 --> 00:40:50,800
hydrogen was generated

1070
00:40:55,589 --> 00:40:51,680
and

1071
00:40:58,390 --> 00:40:55,599
aspects are rather difficult to

1072
00:41:00,950 --> 00:40:58,400
constrain so what happens for example

1073
00:41:03,910 --> 00:41:00,960
during incipient separation and what

1074
00:41:05,750 --> 00:41:03,920
happens over time often

1075
00:41:08,630 --> 00:41:05,760
um pentamites

1076
00:41:10,870 --> 00:41:08,640
on the c4 or nice periodizer are

1077
00:41:12,950 --> 00:41:10,880
strongly to completely altered so not

1078
00:41:14,550 --> 00:41:12,960
allowing us to figure out how we

1079
00:41:17,109 --> 00:41:14,560
actually start out

1080
00:41:20,550 --> 00:41:17,119
so to that end we um

1081
00:41:22,790 --> 00:41:20,560
conducted a several experiments i'm

1082
00:41:25,349 --> 00:41:22,800
showing the results of one of them here

1083
00:41:26,950 --> 00:41:25,359
so the experiments

1084
00:41:29,510 --> 00:41:26,960
are conducted in a flexible cell

1085
00:41:32,470 --> 00:41:29,520
hydrothermal apparatus that allows fluid

1086
00:41:34,470 --> 00:41:32,480
sampling during the experiment

1087
00:41:36,550 --> 00:41:34,480
so this experiment here

1088
00:41:38,230 --> 00:41:36,560

is where we reacted a solid chunk of

1089
00:41:41,270 --> 00:41:38,240
hearthstone guide with artificial sea

1090
00:41:44,069 --> 00:41:41,280
water at 300 degrees c and 350 bar for

1091
00:41:48,069 --> 00:41:44,079
about a year and a half

1092
00:41:50,710 --> 00:41:48,079
and um we used a hearthstone guide

1093
00:41:52,390 --> 00:41:50,720
unaltered hospital guide as

1094
00:41:54,309 --> 00:41:52,400
the starting material here from the

1095
00:41:56,630 --> 00:41:54,319
beautiful method lamar

1096
00:41:59,030 --> 00:41:56,640
and the eiffel volcanic field

1097
00:42:00,870 --> 00:41:59,040
and the advantage of using a solid rock

1098
00:42:03,670 --> 00:42:00,880
instead of powder is that the effects of

1099
00:42:07,030 --> 00:42:03,680
primary textures can be studied that

1100
00:42:08,790 --> 00:42:07,040
reaction rates are probably closer to

1101
00:42:11,190 --> 00:42:08,800
the the real thing to sea flow

1102
00:42:14,230 --> 00:42:11,200
hydrothermal systems

1103
00:42:17,030 --> 00:42:14,240
and that it allows us studying incipient

1104
00:42:18,710 --> 00:42:17,040
repetition the disadvantage

1105
00:42:20,790 --> 00:42:18,720
clearly is that

1106
00:42:22,870 --> 00:42:20,800
the reaction progress is low and that

1107
00:42:25,990 --> 00:42:22,880
experiments cannot go to completion on

1108
00:42:27,829 --> 00:42:26,000
laboratory time scales

1109
00:42:30,069 --> 00:42:27,839
so okay shown here are the measured

1110
00:42:32,230 --> 00:42:30,079
hydrogen concentrations as a function of

1111
00:42:33,829 --> 00:42:32,240
time in comparison to some previous

1112
00:42:35,430 --> 00:42:33,839
experiments

1113
00:42:38,150 --> 00:42:35,440

the hydrogen

1114
00:42:40,950 --> 00:42:38,160
releases rapid at first but then tapers

1115
00:42:43,349 --> 00:42:40,960
off uh with time suggesting that the

1116
00:42:46,150 --> 00:42:43,359
fentonization actually slows down and

1117
00:42:47,910 --> 00:42:46,160
for sure comparison er like estimate for

1118
00:42:50,470 --> 00:42:47,920
reaction rates

1119
00:42:54,470 --> 00:42:51,829
so

1120
00:42:56,790 --> 00:42:54,480
looking at the major or the measured

1121
00:42:58,790 --> 00:42:56,800
major element concentrations of the

1122
00:43:01,030 --> 00:42:58,800
fluid over time it appears that there is

1123
00:43:05,190 --> 00:43:01,040
no significant

1124
00:43:07,510 --> 00:43:05,200
increase in the the the magnesium or or

1125
00:43:10,870 --> 00:43:07,520
silica over time

1126
00:43:12,950 --> 00:43:10,880
while there's an increase in ph

1127
00:43:15,349 --> 00:43:12,960
and there's actually a

1128
00:43:17,990 --> 00:43:15,359
slight decrease in calcium and no

1129
00:43:23,030 --> 00:43:18,000
significant changes in

1130
00:43:26,390 --> 00:43:24,150
so

1131
00:43:28,309 --> 00:43:26,400
the speciated fluid composition can be

1132
00:43:30,630 --> 00:43:28,319
illustrated in an activity activity

1133
00:43:32,710 --> 00:43:30,640
diagram here to check out which minerals

1134
00:43:35,910 --> 00:43:32,720
actually are stable and which ones

1135
00:43:38,630 --> 00:43:35,920
formed and turns out that all of the

1136
00:43:41,349 --> 00:43:38,640
speciated fluid compositions

1137
00:43:43,349 --> 00:43:41,359
fall into the stability field of

1138
00:43:45,670 --> 00:43:43,359

serpentine

1139
00:43:48,870 --> 00:43:45,680
so when we terminated the experiment we

1140
00:43:51,430 --> 00:43:48,880
were we extracted the altered rock and

1141
00:43:53,109 --> 00:43:51,440
or partially altered rocker i should say

1142
00:43:55,829 --> 00:43:53,119
checked out the surface

1143
00:43:57,910 --> 00:43:55,839
we are using an sem

1144
00:44:00,230 --> 00:43:57,920
and which is illustrated here in these

1145
00:44:02,309 --> 00:44:00,240
back scattered electron images so the

1146
00:44:05,750 --> 00:44:02,319
alteration minerals include several

1147
00:44:08,950 --> 00:44:05,760
kinds of serpentines olividide crystal

1148
00:44:11,190 --> 00:44:08,960
polyhedral serpentine as well as

1149
00:44:13,030 --> 00:44:11,200
calcite shown here

1150
00:44:15,829 --> 00:44:13,040
are chloride

1151
00:44:17,990 --> 00:44:15,839
magnetite and nickel sulfide heal would

1152
00:44:20,390 --> 00:44:18,000
diet

1153
00:44:22,470 --> 00:44:20,400
so the other cool thing about using real

1154
00:44:24,790 --> 00:44:22,480
rocks instead of powders and experiments

1155
00:44:26,790 --> 00:44:24,800
that allows you to make thin sections

1156
00:44:29,030 --> 00:44:26,800
and here we are looking at bse uh

1157
00:44:32,069 --> 00:44:29,040
backscale optional images of the rock

1158
00:44:34,870 --> 00:44:32,079
interior what we see is that the main

1159
00:44:37,750 --> 00:44:34,880
reaction product is actually

1160
00:44:39,510 --> 00:44:37,760
lizardite and

1161
00:44:41,910 --> 00:44:39,520
which is

1162
00:44:45,829 --> 00:44:41,920
much more abundant than chrysoteo which

1163
00:44:48,790 --> 00:44:45,839

which forms on the the rock exterior

1164
00:44:52,150 --> 00:44:48,800
so we find magnetite in contact with

1165
00:44:54,710 --> 00:44:52,160
olivine so for example here

1166
00:44:57,270 --> 00:44:54,720
or here which is in contrast to some of

1167
00:45:00,790 --> 00:44:57,280
the recent models pushed by jim beer ron

1168
00:45:06,230 --> 00:45:04,069
and we can see that the cpx here is

1169
00:45:09,190 --> 00:45:06,240
actually stable so it

1170
00:45:12,309 --> 00:45:09,200
remained unaltered and the textures that

1171
00:45:14,550 --> 00:45:12,319
we see here our bath side textures or

1172
00:45:15,829 --> 00:45:14,560
mesh texture are remarkably similar to

1173
00:45:17,990 --> 00:45:15,839
what we see

1174
00:45:20,230 --> 00:45:18,000
in sea fluorescent pentamites and we

1175
00:45:22,950 --> 00:45:20,240
find fractures at the end of these

1176
00:45:24,309 --> 00:45:22,960
cone-shaped etch pits that extend into

1177
00:45:27,990 --> 00:45:24,319
the rock

1178
00:45:30,150 --> 00:45:28,000
lastly the the the pentagonite is is

1179
00:45:33,670 --> 00:45:30,160
only partial or the prototype is only

1180
00:45:36,230 --> 00:45:33,680
partially separate so there's lots of

1181
00:45:37,670 --> 00:45:36,240
unreacted material left

1182
00:45:39,670 --> 00:45:37,680
so we can

1183
00:45:41,349 --> 00:45:39,680
approximate the extent of alteration

1184
00:45:42,630 --> 00:45:41,359
using different techniques such as

1185
00:45:44,550 --> 00:45:42,640
density

1186
00:45:46,710 --> 00:45:44,560
magnetization saturation hydrogen

1187
00:45:49,109 --> 00:45:46,720
generation image analysis and all of

1188
00:45:51,910 --> 00:45:49,119

these techniques gives us approximately

1189
00:45:55,109 --> 00:45:51,920
four to five percent of uh reaction

1190
00:45:57,109 --> 00:45:55,119
um comparing that with um

1191
00:45:58,790 --> 00:45:57,119
published conversion rates per day it

1192
00:46:00,790 --> 00:45:58,800
turns out that the rates that we're

1193
00:46:03,030 --> 00:46:00,800
getting in the rock chunk uh

1194
00:46:06,630 --> 00:46:03,040
separatisation experiment are

1195
00:46:09,510 --> 00:46:06,640
really slow in fact the the slowest um

1196
00:46:11,750 --> 00:46:09,520
measured so far for surpationization at

1197
00:46:12,550 --> 00:46:11,760
300 degrees c

1198
00:46:14,950 --> 00:46:12,560
and

1199
00:46:17,829 --> 00:46:14,960
given that we had no significant changes

1200
00:46:19,349 --> 00:46:17,839
in the major element compositions uh

1201
00:46:22,069 --> 00:46:19,359
regarding

1202
00:46:24,309 --> 00:46:22,079
magnesium and silica and that olivine

1203
00:46:25,030 --> 00:46:24,319
and orthoparoxine

1204
00:46:26,069 --> 00:46:25,040
are

1205
00:46:33,910 --> 00:46:26,079
the

1206
00:46:35,670 --> 00:46:33,920
major hydrous alteration mineral we

1207
00:46:38,150 --> 00:46:35,680
calculate that this reaction must have

1208
00:46:40,470 --> 00:46:38,160
led to a volume increase of about 40

1209
00:46:42,870 --> 00:46:40,480
percent at least under the experimental

1210
00:46:44,790 --> 00:46:42,880
conditions there's some discussion about

1211
00:46:47,349 --> 00:46:44,800
volume changes and mass transfer during

1212
00:46:48,710 --> 00:46:47,359
separatisation and in other

1213
00:46:49,589 --> 00:46:48,720

conditions

1214
00:46:52,150 --> 00:46:49,599
so

1215
00:46:53,750 --> 00:46:52,160
the volume increase led to a decreased

1216
00:46:55,510 --> 00:46:53,760
access to water

1217
00:46:56,390 --> 00:46:55,520
to primary minerals

1218
00:46:58,630 --> 00:46:56,400
and

1219
00:47:01,109 --> 00:46:58,640
fresh mineral surfaces also due to

1220
00:47:03,109 --> 00:47:01,119
filling of fractures and coating effects

1221
00:47:05,270 --> 00:47:03,119
and so the system becomes increasingly

1222
00:47:06,630 --> 00:47:05,280
diffusion controlled

1223
00:47:07,510 --> 00:47:06,640
and

1224
00:47:09,670 --> 00:47:07,520
that

1225
00:47:11,910 --> 00:47:09,680
can explain the decreased rates of the

1226
00:47:14,950 --> 00:47:11,920
pentatonization on hydrogen

1227
00:47:17,109 --> 00:47:14,960
release over time

1228
00:47:19,910 --> 00:47:17,119
however we know from c-force of

1229
00:47:21,829 --> 00:47:19,920
pentatonites that they are actually

1230
00:47:23,750 --> 00:47:21,839
you know in many cases a completely

1231
00:47:24,710 --> 00:47:23,760
isopentane knife

1232
00:47:27,270 --> 00:47:24,720
and

1233
00:47:31,190 --> 00:47:27,280
i think one of the key factors here is

1234
00:47:33,270 --> 00:47:31,200
fracturing so fracturing allows water to

1235
00:47:35,430 --> 00:47:33,280
access

1236
00:47:37,829 --> 00:47:35,440
the primary minerals and allows these

1237
00:47:40,470 --> 00:47:37,839
reactions to proceed more rapidly and

1238
00:47:42,230 --> 00:47:40,480

that can be due to

1239
00:47:44,549 --> 00:47:42,240
reaction-driven fracturing as it is

1240
00:47:45,349 --> 00:47:44,559
likely the case here or it can be

1241
00:47:47,670 --> 00:47:45,359
through

1242
00:47:49,349 --> 00:47:47,680
tectonic fracturing or even thermal

1243
00:47:50,870 --> 00:47:49,359
fracturing

1244
00:47:53,510 --> 00:47:50,880
so

1245
00:47:55,589 --> 00:47:53,520
the last point i want to uh point out or

1246
00:47:57,030 --> 00:47:55,599
thing i want to point out is that

1247
00:47:59,109 --> 00:47:57,040
um

1248
00:48:02,150 --> 00:47:59,119
we have also some mass balance

1249
00:48:04,309 --> 00:48:02,160
constraints on the the reaction pathways

1250
00:48:08,309 --> 00:48:04,319
during spectralization um

1251
00:48:10,950 --> 00:48:08,319
and and this is because we know

1252
00:48:13,750 --> 00:48:10,960
that the um horizon guide has about four

1253
00:48:16,069 --> 00:48:13,760
times more olivine than orthoparoxy um

1254
00:48:18,069 --> 00:48:16,079
in order to mass balance uh this

1255
00:48:20,069 --> 00:48:18,079
reaction um

1256
00:48:21,109 --> 00:48:20,079
knowing that serpentine is the only

1257
00:48:23,750 --> 00:48:21,119
major

1258
00:48:26,069 --> 00:48:23,760
uh reaction product and at least doing

1259
00:48:27,349 --> 00:48:26,079
initial separation

1260
00:48:29,190 --> 00:48:27,359
um

1261
00:48:31,270 --> 00:48:29,200
the orthopedic scene actually had to

1262
00:48:34,470 --> 00:48:31,280
react about two times faster than the

1263
00:48:35,829 --> 00:48:34,480

olivine to make this uh reaction uh

1264
00:48:37,190 --> 00:48:35,839
happen here

1265
00:48:39,910 --> 00:48:37,200
um so but

1266
00:48:42,150 --> 00:48:39,920
this is only the the initial part

1267
00:48:44,309 --> 00:48:42,160
um

1268
00:48:46,549 --> 00:48:44,319
what happens next so during advanced

1269
00:48:49,349 --> 00:48:46,559
dependentization and shown here are the

1270
00:48:51,270 --> 00:48:49,359
results from a powder experiment using

1271
00:48:54,150 --> 00:48:51,280
the same starting material

1272
00:48:57,109 --> 00:48:55,510
that

1273
00:48:58,950 --> 00:48:57,119
in this experiment

1274
00:49:00,630 --> 00:48:58,960
the the final

1275
00:49:03,270 --> 00:49:00,640
equilibrium mineralism which was

1276
00:49:07,109 --> 00:49:03,280
actually reached which is um

1277
00:49:09,750 --> 00:49:07,119
serpentine brucite and and cpx but only

1278
00:49:12,950 --> 00:49:09,760
after the orthopedic scene was exhausted

1279
00:49:14,950 --> 00:49:12,960
so we know the orthodoxy reacted faster

1280
00:49:18,390 --> 00:49:14,960
but it's also less abundant which means

1281
00:49:21,109 --> 00:49:18,400
that it will be exhausted first and then

1282
00:49:23,430 --> 00:49:21,119
the reaction of olivine

1283
00:49:25,750 --> 00:49:23,440
becomes the dominant so so we have a

1284
00:49:28,829 --> 00:49:25,760
two-step reaction sequence uh

1285
00:49:31,990 --> 00:49:28,839
illustrated here and in fact the

1286
00:49:34,230 --> 00:49:32,000
the the final assemblage here was uh

1287
00:49:36,950 --> 00:49:34,240
serpentine brewsight cpx bank type

1288
00:49:38,630 --> 00:49:36,960

chloride and calcite

1289
00:49:41,510 --> 00:49:38,640
and the calcite formed under strongly

1290
00:49:43,910 --> 00:49:41,520
reducing conditions there was about 100

1291
00:49:45,190 --> 00:49:43,920
millimoles of a hydrogen per kilogram of

1292
00:49:47,430 --> 00:49:45,200
fluid

1293
00:49:49,589 --> 00:49:47,440
so um

1294
00:49:51,109 --> 00:49:49,599
anyhow i think it came across that the

1295
00:49:52,950 --> 00:49:51,119
reaction pathways and hydrogen

1296
00:49:55,670 --> 00:49:52,960
generation during the pectinization

1297
00:49:57,270 --> 00:49:55,680
depend on the product composition and on

1298
00:49:59,430 --> 00:49:57,280
the temperature dependent phase

1299
00:50:01,109 --> 00:49:59,440
relations and relative reaction rates of

1300
00:50:04,549 --> 00:50:01,119
the primary minerals

1301
00:50:06,069 --> 00:50:04,559
uh sepentenization it can be a volume

1302
00:50:08,470 --> 00:50:06,079
increasing process

1303
00:50:10,390 --> 00:50:08,480
maybe not under all circumstances and

1304
00:50:12,630 --> 00:50:10,400
that the rates of sepantonization

1305
00:50:14,710 --> 00:50:12,640
hydrogen generation are slower in these

1306
00:50:15,990 --> 00:50:14,720
rock chunk experiments than

1307
00:50:17,510 --> 00:50:16,000
in powder

1308
00:50:19,430 --> 00:50:17,520
experiments

1309
00:50:21,990 --> 00:50:19,440
and and even though they are slower they

1310
00:50:23,109 --> 00:50:22,000
seem to be like still fast enough to to

1311
00:50:26,309 --> 00:50:23,119
support

1312
00:50:29,190 --> 00:50:26,319
uh microbial ecosystems with energy and

1313
00:50:31,990 --> 00:50:29,200

so the rates of the i would rather call

1314
00:50:34,309 --> 00:50:32,000
it actually the reaction progress

1315
00:50:35,910 --> 00:50:34,319
seems to be limited by a fluid access to

1316
00:50:38,150 --> 00:50:35,920
primary minerals

1317
00:50:39,510 --> 00:50:38,160
okay so uh with that uh thank you for

1318
00:50:42,390 --> 00:50:39,520
your attention and happy to take any

1319
00:50:47,030 --> 00:50:44,549
all right thank you very much frieder

1320
00:50:50,230 --> 00:50:47,040
uh we do have a couple of questions uh

1321
00:50:52,069 --> 00:50:50,240
on the web one is from uh adrian brown

1322
00:50:53,990 --> 00:50:52,079
and he was wondering

1323
00:50:55,990 --> 00:50:54,000
uh whether there was any saponite in

1324
00:50:57,750 --> 00:50:56,000
your mineral probably in your reaction

1325
00:51:00,150 --> 00:50:57,760
products and if not

1326
00:51:03,829 --> 00:51:00,160
why not

1327
00:51:05,589 --> 00:51:03,839
okay so saponide um is a mineral that we

1328
00:51:09,190 --> 00:51:05,599
do find in

1329
00:51:11,670 --> 00:51:09,200
um subpentenization systems that have

1330
00:51:15,270 --> 00:51:11,680
elevated the silica activity

1331
00:51:18,390 --> 00:51:15,280
and in fact we did find it in

1332
00:51:21,109 --> 00:51:18,400
one experiment where we injected a co2

1333
00:51:23,829 --> 00:51:21,119
rich fluid and so the saponide formed

1334
00:51:26,069 --> 00:51:23,839
together with dolomite so this used to

1335
00:51:28,950 --> 00:51:26,079
be an effect of

1336
00:51:31,190 --> 00:51:28,960
silica activity and the silica activity

1337
00:51:32,790 --> 00:51:31,200
is influenced or can be influenced by

1338
00:51:35,270 --> 00:51:32,800

for example interaction with garboy

1339
00:51:37,829 --> 00:51:35,280
fluids but it can also increase due to

1340
00:51:42,870 --> 00:51:37,839
injection of co2 rich fluids due to

1341
00:51:47,750 --> 00:51:44,790
okay we also had a question about what

1342
00:51:50,309 --> 00:51:47,760
the ph of the fluids in the experiments

1343
00:51:52,549 --> 00:51:50,319
was

1344
00:51:54,470 --> 00:51:52,559
um so the ph

1345
00:51:56,950 --> 00:51:54,480
of the fluids in the experiments in the

1346
00:51:58,150 --> 00:51:56,960
rock chunk experiment had increased to

1347
00:52:00,870 --> 00:51:58,160
about

1348
00:52:03,430 --> 00:52:00,880
nine and a half that's measured at

1349
00:52:05,829 --> 00:52:03,440
room temperature however

1350
00:52:08,950 --> 00:52:05,839
the powder experiment went all the way

1351
00:52:10,630 --> 00:52:08,960
up to uh ph 11 at 25 degrees ceo

1352
00:52:14,549 --> 00:52:10,640
actually a little higher than that which

1353
00:52:27,589 --> 00:52:14,559
is consistent with the cpx brewside

1354
00:52:31,750 --> 00:52:29,910
oh there was uh

1355
00:52:33,510 --> 00:52:31,760
yes it says he's a will god i did not

1356
00:52:35,190 --> 00:52:33,520
know that he's a wood-eyed is a rare

1357
00:52:36,630 --> 00:52:35,200
sulfur poor

1358
00:52:38,710 --> 00:52:36,640
nickel sulfide mineral found in

1359
00:52:40,870 --> 00:52:38,720
serpentinized dynamite

1360
00:52:43,670 --> 00:52:40,880
yeah so these uh the hello diet is cool

1361
00:52:45,910 --> 00:52:43,680
um so it forms as a

1362
00:52:47,990 --> 00:52:45,920
reaction product during desulphurization

1363
00:52:50,790 --> 00:52:48,000

of primary minerals which can be

1364
00:52:53,750 --> 00:52:50,800
peritide uh

1365
00:52:55,430 --> 00:52:53,760
monosulfide solid solution or pentlanite

1366
00:52:58,150 --> 00:52:55,440
and um

1367
00:53:01,589 --> 00:52:58,160
he's what is one of many possible nickel

1368
00:53:04,150 --> 00:53:01,599
sulfides that actually do have uh

1369
00:53:06,150 --> 00:53:04,160
astrobiological relevance and also to

1370
00:53:08,230 --> 00:53:06,160
the origin of life as some of these

1371
00:53:10,150 --> 00:53:08,240
nickel iron sulfides

1372
00:53:12,950 --> 00:53:10,160
are also found

1373
00:53:14,710 --> 00:53:12,960
in the cores of enzymes

1374
00:53:16,950 --> 00:53:14,720
and um

1375
00:53:19,349 --> 00:53:16,960
uh so one last question

1376
00:53:21,589 --> 00:53:19,359
yeah uh was about the uh the mineral

1377
00:53:23,190 --> 00:53:21,599
pairs used in the iso oxygen isotope

1378
00:53:29,270 --> 00:53:23,200
thermometry

1379
00:53:31,270 --> 00:53:29,280
not done uh using mineral pairs it was

1380
00:53:32,910 --> 00:53:31,280
used we used

1381
00:53:36,950 --> 00:53:32,920
peter sakosha's

1382
00:53:38,309 --> 00:53:36,960
2008 serpentine seawater oxygenized tilt

1383
00:53:39,510 --> 00:53:38,319
thermometer

1384
00:53:42,069 --> 00:53:39,520
and

1385
00:53:44,309 --> 00:53:42,079
the serpentine magnetite oxygen isotope

1386
00:53:47,190 --> 00:53:44,319
thermometer is not experimentally

1387
00:53:50,069 --> 00:53:47,200
calibrated and and can give really

1388
00:53:52,390 --> 00:53:50,079

unrealistic values if

1389
00:53:54,829 --> 00:53:52,400
the serpentine and magnetite are not in

1390
00:53:58,470 --> 00:53:54,839
equilibrium that's sometimes hard to

1391
00:54:00,950 --> 00:53:58,480
establish okay we have time for one last

1392
00:54:03,589 --> 00:54:00,960
question from cody lazar

1393
00:54:06,309 --> 00:54:03,599
and he was asking if uh if magnetite

1394
00:54:09,829 --> 00:54:06,319
free bruceite serpentine

1395
00:54:12,069 --> 00:54:09,839
serpent knight serpentine assembly has a

1396
00:54:15,030 --> 00:54:12,079
then what would be controlling the fo2

1397
00:54:17,349 --> 00:54:15,040
if not magnetite equilibria

1398
00:54:22,309 --> 00:54:17,359
right and so i had this in my original

1399
00:54:24,630 --> 00:54:22,319
presentation that i wanted to to show

1400
00:54:26,230 --> 00:54:24,640
but i thought it would get too long

1401
00:54:28,950 --> 00:54:26,240
um the

1402
00:54:32,710 --> 00:54:28,960
the um controlling equilibria are

1403
00:54:35,829 --> 00:54:32,720
between iron uh bearing bruceite um and

1404
00:54:38,390 --> 00:54:35,839
and iron and serpentine as well as i

1405
00:54:40,630 --> 00:54:38,400
didn't show this or point this out

1406
00:54:42,549 --> 00:54:40,640
on the slide actually android in this

1407
00:54:43,349 --> 00:54:42,559
particular system so

1408
00:54:44,150 --> 00:54:43,359
and

1409
00:54:49,109 --> 00:54:44,160
the

1410
00:54:51,349 --> 00:54:49,119
concentrations that are in equilibrium

1411
00:54:52,950 --> 00:54:51,359
with the ovarite and the pentanoid and

1412
00:54:55,349 --> 00:54:52,960
they depending on temperature they were

1413
00:54:57,589 --> 00:54:55,359

on the orders of tens to maybe hundreds

1414
00:55:01,430 --> 00:54:57,599
of millimoles of hydrogen

1415
00:55:06,309 --> 00:55:03,589
wait thank you again frieder uh we're

1416
00:55:08,789 --> 00:55:06,319
going to move on now and and our next

1417
00:55:10,549 --> 00:55:08,799
presenter is going to be uh lisa mayhew

1418
00:55:13,829 --> 00:55:10,559
here at the university of colorado so i

1419
00:55:15,829 --> 00:55:13,839
will turn it over to lisa all right

1420
00:55:17,670 --> 00:55:15,839
thank you very much tom

1421
00:55:19,270 --> 00:55:17,680
um i want to thank tom for inviting me

1422
00:55:20,789 --> 00:55:19,280
to speak here

1423
00:55:21,829 --> 00:55:20,799
and

1424
00:55:23,990 --> 00:55:21,839
um

1425
00:55:25,190 --> 00:55:24,000
also comment

1426
00:55:27,109 --> 00:55:25,200
because i figure out how to make my

1427
00:55:29,109 --> 00:55:27,119
slides

1428
00:55:30,309 --> 00:55:29,119
there um

1429
00:55:31,829 --> 00:55:30,319
that i'm going to be

1430
00:55:33,750 --> 00:55:31,839
i'm a research scientist in alexis

1431
00:55:35,430 --> 00:55:33,760
templeton's lab here at the university

1432
00:55:38,150 --> 00:55:35,440
of colorado in boulder and i'm going to

1433
00:55:40,150 --> 00:55:38,160
be talking about work that i have done

1434
00:55:41,829 --> 00:55:40,160
and close collaboration with eric

1435
00:55:42,789 --> 00:55:41,839
ellison and hannah miller who are both

1436
00:55:44,710 --> 00:55:42,799
members

1437
00:55:46,230 --> 00:55:44,720
of alexis's lab as well and we've each

1438
00:55:47,109 --> 00:55:46,240

sort of spearheaded different parts of

1439
00:55:49,349 --> 00:55:47,119
this

1440
00:55:54,789 --> 00:55:49,359
the work that will be presented um

1441
00:55:57,670 --> 00:55:55,990
i know these

1442
00:55:59,750 --> 00:55:57,680
things use the keyboard the right arrow

1443
00:56:00,950 --> 00:55:59,760
from now on okay thanks

1444
00:56:02,710 --> 00:56:00,960
um

1445
00:56:04,710 --> 00:56:02,720
all right so freder made my job of

1446
00:56:06,230 --> 00:56:04,720
introducing this so much easier than it

1447
00:56:09,349 --> 00:56:06,240
would have been had he not gone first

1448
00:56:12,950 --> 00:56:09,359
but um just to remind everybody that

1449
00:56:15,829 --> 00:56:12,960
um if we take a look via sort of a

1450
00:56:17,990 --> 00:56:15,839
i think this is 10 or 20 x photo

1451
00:56:20,549 --> 00:56:18,000
in plain polarized light of a partially

1452
00:56:24,309 --> 00:56:20,559
serpentinized rock we can see that they

1453
00:56:25,670 --> 00:56:24,319
have possessed a complex mineralogy and

1454
00:56:27,829 --> 00:56:25,680
we're hopeful that this complex

1455
00:56:29,190 --> 00:56:27,839
mineralogy is representative of a

1456
00:56:31,510 --> 00:56:29,200
reaction path history that they've

1457
00:56:33,190 --> 00:56:31,520
undergone in a way that we can actually

1458
00:56:34,390 --> 00:56:33,200
unravel through use of a number of

1459
00:56:36,150 --> 00:56:34,400
different

1460
00:56:36,950 --> 00:56:36,160
analytical techniques

1461
00:56:39,510 --> 00:56:36,960
um

1462
00:56:41,349 --> 00:56:39,520
to sort of understand the

1463
00:56:44,870 --> 00:56:41,359

the pathways that these rocks take to go

1464
00:56:47,430 --> 00:56:44,880
from an unaltered prototype to um

1465
00:56:49,109 --> 00:56:47,440
an altered serpentinite

1466
00:56:51,510 --> 00:56:49,119
and we need to figure out how the

1467
00:56:54,069 --> 00:56:51,520
primary phases like olivine and pyroxene

1468
00:56:55,510 --> 00:56:54,079
um and chromite are related to

1469
00:56:58,230 --> 00:56:55,520
secondary phases

1470
00:57:01,190 --> 00:56:58,240
for instance serpentine and magnetite

1471
00:57:02,870 --> 00:57:01,200
and my main interest is

1472
00:57:05,349 --> 00:57:02,880
trying to tease apart the redox

1473
00:57:07,349 --> 00:57:05,359
transformations of iron that

1474
00:57:09,349 --> 00:57:07,359
take place during these reactions at low

1475
00:57:13,430 --> 00:57:09,359
temperature and i'm not going to go into

1476
00:57:16,069 --> 00:57:13,440
these plots in great detail because um

1477
00:57:17,750 --> 00:57:16,079
frieder did in their his plots

1478
00:57:18,630 --> 00:57:17,760
where's my pointer

1479
00:57:21,109 --> 00:57:18,640
okay

1480
00:57:23,670 --> 00:57:21,119
um but again you can see

1481
00:57:24,789 --> 00:57:23,680
that magnetite in terms of being a phase

1482
00:57:26,470 --> 00:57:24,799
that precipitates out during

1483
00:57:28,309 --> 00:57:26,480
serpentinization and that can

1484
00:57:31,190 --> 00:57:28,319
accommodate iron iii

1485
00:57:33,829 --> 00:57:31,200
that forms during the reaction or from

1486
00:57:36,870 --> 00:57:33,839
the oxidation of iron ii really doesn't

1487
00:57:38,069 --> 00:57:36,880
become much of a player until about 175

1488
00:57:40,950 --> 00:57:38,079

degrees c

1489
00:57:42,470 --> 00:57:40,960
whereas bruce site and serpentine

1490
00:57:43,829 --> 00:57:42,480
are much more prevalent at these lower

1491
00:57:46,309 --> 00:57:43,839
temperatures

1492
00:57:48,470 --> 00:57:46,319
and then in this plot frieder has shown

1493
00:57:49,910 --> 00:57:48,480
essentially the contribution of iron or

1494
00:57:51,829 --> 00:57:49,920
the the amount of iron in these

1495
00:57:54,390 --> 00:57:51,839
different phases and you can see that

1496
00:57:55,910 --> 00:57:54,400
that brew site contains iron

1497
00:57:58,309 --> 00:57:55,920
at much higher

1498
00:57:59,510 --> 00:57:58,319
concentrations at lower temperatures and

1499
00:58:01,750 --> 00:57:59,520
these are the temperatures that i'm

1500
00:58:04,309 --> 00:58:01,760
interested in thinking about

1501
00:58:06,789 --> 00:58:04,319
these dependentization reactions

1502
00:58:09,349 --> 00:58:06,799
and so the question is

1503
00:58:11,990 --> 00:58:09,359
at these low temperatures

1504
00:58:14,309 --> 00:58:12,000
um what phases are the reservoirs for

1505
00:58:15,829 --> 00:58:14,319
iron two that might be reacting

1506
00:58:17,190 --> 00:58:15,839
especially if you're

1507
00:58:20,710 --> 00:58:17,200
starting with an already partially

1508
00:58:24,390 --> 00:58:20,720
reacted rock and then what phases form

1509
00:58:27,670 --> 00:58:26,630
as that reaction progresses and so the

1510
00:58:30,230 --> 00:58:27,680
challenge

1511
00:58:32,309 --> 00:58:30,240
oh and then if we consider other

1512
00:58:33,109 --> 00:58:32,319
possible alternative

1513
00:58:34,710 --> 00:58:33,119

uh

1514
00:58:36,870 --> 00:58:34,720
secondary phase

1515
00:58:39,510 --> 00:58:36,880
phases that might form besides magnetite

1516
00:58:41,990 --> 00:58:39,520
which is shown in black this work by

1517
00:58:44,950 --> 00:58:42,000
wolfgang bach recently was kinetic

1518
00:58:47,829 --> 00:58:44,960
models whereas frieders models were

1519
00:58:51,109 --> 00:58:47,839
thermodynamic equilibrium models

1520
00:58:52,870 --> 00:58:51,119
you can see that we can make hydrogen

1521
00:58:54,870 --> 00:58:52,880
if we put iron three into phases other

1522
00:58:56,789 --> 00:58:54,880
than magnetite including things like

1523
00:58:59,190 --> 00:58:56,799
iron three oxides like gertite and

1524
00:59:00,309 --> 00:58:59,200
hematite and also cronstatite and iron

1525
00:59:04,950 --> 00:59:00,319
and member

1526
00:59:07,270 --> 00:59:04,960
so

1527
00:59:08,390 --> 00:59:07,280
how do we unravel

1528
00:59:09,589 --> 00:59:08,400
all of the relationships of the

1529
00:59:11,750 --> 00:59:09,599
mineralogy

1530
00:59:15,190 --> 00:59:11,760
and how do we do it on a on a micro

1531
00:59:18,710 --> 00:59:15,200
scale these are the questions that we're

1532
00:59:20,789 --> 00:59:18,720
trying to work on at this point and so

1533
00:59:24,069 --> 00:59:20,799
a key component of this then is having

1534
00:59:25,030 --> 00:59:24,079
the appropriate rock samples to work on

1535
00:59:25,829 --> 00:59:25,040
and

1536
00:59:29,670 --> 00:59:25,839
um

1537
00:59:33,190 --> 00:59:29,680
we're studying were introduced by folks

1538
00:59:34,789 --> 00:59:33,200

like billy and beth and everett and so

1539
00:59:37,270 --> 00:59:34,799
i'm just going to

1540
00:59:39,829 --> 00:59:37,280
talk briefly here about lost city and

1541
00:59:41,109 --> 00:59:39,839
again billy mentioned that really most

1542
00:59:42,950 --> 00:59:41,119
of the previous work has been done on

1543
00:59:45,829 --> 00:59:42,960
these chimney structures

1544
00:59:50,230 --> 00:59:45,839
and these are images from the cruise to

1545
00:59:52,309 --> 00:59:50,240
velocity back in 2008 that i went on

1546
00:59:55,030 --> 00:59:52,319
and most of the work then focused on

1547
00:59:57,030 --> 00:59:55,040
getting fluids oh that didn't

1548
00:59:58,950 --> 00:59:57,040
sorry it's not quite the right order but

1549
01:00:00,549 --> 00:59:58,960
fluids from these chimneys

1550
01:00:01,589 --> 01:00:00,559
and i was interested in actually

1551
01:00:04,069 --> 01:00:01,599
obtaining

1552
01:00:06,230 --> 01:00:04,079
the underlying rocks because i wanted to

1553
01:00:07,510 --> 01:00:06,240
know even back then what

1554
01:00:09,750 --> 01:00:07,520
what do those rocks look like and how

1555
01:00:11,750 --> 01:00:09,760
might they be producing

1556
01:00:13,109 --> 01:00:11,760
hydrogen but at that time all we had

1557
01:00:14,870 --> 01:00:13,119
access to was

1558
01:00:17,190 --> 01:00:14,880
taking the rob jason and trying to get

1559
01:00:20,309 --> 01:00:17,200
him to pull rocks out of the

1560
01:00:23,510 --> 01:00:20,319
um fault scarp that underlied lost city

1561
01:00:25,109 --> 01:00:23,520
um whereas with the expedition that beth

1562
01:00:27,270 --> 01:00:25,119
spoke about yesterday

1563
01:00:29,270 --> 01:00:27,280

of which i'm a science party member

1564
01:00:31,510 --> 01:00:29,280
we're actually able to drill down into

1565
01:00:34,390 --> 01:00:31,520
the subsurface of velocity and get these

1566
01:00:37,510 --> 01:00:34,400
drill core materials that now we can

1567
01:00:39,510 --> 01:00:37,520
study in more detail and we can see

1568
01:00:41,190 --> 01:00:39,520
even from a plane polarized

1569
01:00:43,589 --> 01:00:41,200
light photomicrograph but they're very

1570
01:00:45,910 --> 01:00:43,599
complex

1571
01:00:47,510 --> 01:00:45,920
materials and

1572
01:00:49,670 --> 01:00:47,520
so we're really excited to have these

1573
01:00:51,510 --> 01:00:49,680
rocks in hand now and they're some of i

1574
01:00:53,589 --> 01:00:51,520
think the most promising and exciting

1575
01:00:56,150 --> 01:00:53,599
samples we have especially because

1576
01:00:58,309 --> 01:00:56,160
the work that i'll be doing on iron

1577
01:00:59,910 --> 01:00:58,319
speciation will be coupled with work

1578
01:01:01,910 --> 01:00:59,920
such as

1579
01:01:04,150 --> 01:01:01,920
billy and matt are doing with molecular

1580
01:01:06,309 --> 01:01:04,160
and beth molecular and microbiological

1581
01:01:09,030 --> 01:01:06,319
techniques

1582
01:01:10,950 --> 01:01:09,040
to try to correlate with what organisms

1583
01:01:13,990 --> 01:01:10,960
might be living in these systems and

1584
01:01:15,270 --> 01:01:14,000
also work with benedict menez from ipgp

1585
01:01:17,910 --> 01:01:15,280
in paris to look at the carbon

1586
01:01:19,109 --> 01:01:17,920
speciation so there's a lot of i think

1587
01:01:20,390 --> 01:01:19,119
um

1588
01:01:22,470 --> 01:01:20,400

power in

1589
01:01:24,870 --> 01:01:22,480
these sorts of

1590
01:01:27,109 --> 01:01:24,880
um expeditions where we can all

1591
01:01:28,309 --> 01:01:27,119
work on the same samples

1592
01:01:30,230 --> 01:01:28,319
but all that being said i'm not going to

1593
01:01:30,950 --> 01:01:30,240
talk about those today at all

1594
01:01:32,789 --> 01:01:30,960
um

1595
01:01:35,030 --> 01:01:32,799
because there's still a work in progress

1596
01:01:37,030 --> 01:01:35,040
so then moving to oman ever introduced

1597
01:01:39,430 --> 01:01:37,040
this system to us yesterday with these

1598
01:01:42,309 --> 01:01:39,440
beautiful images of hyper alkaline

1599
01:01:43,270 --> 01:01:42,319
springs seeping from the subsurface

1600
01:01:44,710 --> 01:01:43,280
and

1601
01:01:46,630 --> 01:01:44,720
um

1602
01:01:48,710 --> 01:01:46,640
mentioned also showed plots of the

1603
01:01:49,829 --> 01:01:48,720
hydrogen that they measure from these

1604
01:01:53,430 --> 01:01:49,839
sorts of

1605
01:01:54,870 --> 01:01:53,440
and

1606
01:01:57,670 --> 01:01:54,880
again the question here that i'm

1607
01:01:59,750 --> 01:01:57,680
interested in is what are the processes

1608
01:02:01,510 --> 01:01:59,760
that are going on in the subsurface that

1609
01:02:03,109 --> 01:02:01,520
produce that hydrogen

1610
01:02:05,109 --> 01:02:03,119
so

1611
01:02:08,390 --> 01:02:05,119
the oman drilling project which just got

1612
01:02:10,870 --> 01:02:08,400
started in december of 2016

1613
01:02:12,710 --> 01:02:10,880

is now pulling up some of its first

1614
01:02:14,390 --> 01:02:12,720
few hundred meters of core

1615
01:02:16,710 --> 01:02:14,400
um this this is actually a photo of

1616
01:02:17,990 --> 01:02:16,720
olivine gabros um

1617
01:02:20,870 --> 01:02:18,000
and i think you heard a little bit about

1618
01:02:22,950 --> 01:02:20,880
this from katy perhaps yesterday too but

1619
01:02:26,710 --> 01:02:22,960
we're going to have access to core from

1620
01:02:28,789 --> 01:02:26,720
actively serpentinizing regions in oman

1621
01:02:30,069 --> 01:02:28,799
and we're really excited again to look

1622
01:02:32,789 --> 01:02:30,079
at these

1623
01:02:35,750 --> 01:02:32,799
rocks in the context of of also having

1624
01:02:38,710 --> 01:02:35,760
coupled geochemical and microbiological

1625
01:02:40,470 --> 01:02:38,720
measurements on them um

1626
01:02:41,270 --> 01:02:40,480
and then we're excited about this

1627
01:02:44,150 --> 01:02:41,280
because then we'll be able to

1628
01:02:46,309 --> 01:02:44,160
investigate the mineralogy and able to

1629
01:02:48,549 --> 01:02:46,319
try to pin down what processes are

1630
01:02:50,630 --> 01:02:48,559
making the hydrogen that then everett

1631
01:02:52,870 --> 01:02:50,640
and others are measuring in

1632
01:02:54,950 --> 01:02:52,880
the springs and in the well waters that

1633
01:02:55,910 --> 01:02:54,960
are being sampled

1634
01:02:57,430 --> 01:02:55,920
so

1635
01:02:58,470 --> 01:02:57,440
this does beg another question though

1636
01:02:59,349 --> 01:02:58,480
and that's

1637
01:03:02,470 --> 01:02:59,359
what

1638
01:03:04,390 --> 01:03:02,480

mineral phases again

1639
01:03:06,069 --> 01:03:04,400
actually are preserved in these rocks

1640
01:03:08,710 --> 01:03:06,079
that might represent the reaction

1641
01:03:10,870 --> 01:03:08,720
history um it might be signatures of

1642
01:03:13,670 --> 01:03:10,880
what's happening that are representative

1643
01:03:15,670 --> 01:03:13,680
of past hydrogen production

1644
01:03:17,670 --> 01:03:15,680
and so just to tie it back to

1645
01:03:20,630 --> 01:03:17,680
astrobiology it's these sorts of

1646
01:03:23,589 --> 01:03:20,640
questions that we hope to inform when

1647
01:03:26,549 --> 01:03:23,599
we think about looking at or for these

1648
01:03:28,470 --> 01:03:26,559
minerals on other planets um beth and

1649
01:03:31,670 --> 01:03:28,480
yellman's work has

1650
01:03:34,069 --> 01:03:31,680
and i can't tell my pointers um

1651
01:03:36,789 --> 01:03:34,079
duns has done some remote sensing to and

1652
01:03:38,309 --> 01:03:36,799
detected serpentine minerals on the

1653
01:03:39,670 --> 01:03:38,319
surface of mars

1654
01:03:40,549 --> 01:03:39,680
um

1655
01:03:42,789 --> 01:03:40,559
and so

1656
01:03:44,630 --> 01:03:42,799
what does that detection represent in

1657
01:03:46,230 --> 01:03:44,640
terms of a reaction history and does it

1658
01:03:48,470 --> 01:03:46,240
represent

1659
01:03:50,630 --> 01:03:48,480
past hydrogen production

1660
01:03:54,150 --> 01:03:50,640
perhaps in the subsurface of mars and we

1661
01:03:56,829 --> 01:03:54,160
want to inform that discussion as well

1662
01:04:02,069 --> 01:03:59,750
so uh

1663
01:04:04,230 --> 01:04:02,079

we haven't had access into much of those

1664
01:04:06,390 --> 01:04:04,240
subsurface materials until really

1665
01:04:08,150 --> 01:04:06,400
recently so we've been developing

1666
01:04:10,630 --> 01:04:08,160
our analytical techniques and conducting

1667
01:04:12,710 --> 01:04:10,640
our experiments on the wide range of

1668
01:04:16,789 --> 01:04:12,720
surface materials that we have available

1669
01:04:18,470 --> 01:04:16,799
to us and in that case oman is a great

1670
01:04:21,270 --> 01:04:18,480
case study sort of natural laboratory

1671
01:04:23,430 --> 01:04:21,280
where we see a wide diversity of

1672
01:04:26,390 --> 01:04:23,440
rock types in the chemical complexity of

1673
01:04:28,309 --> 01:04:26,400
serpentinites

1674
01:04:30,549 --> 01:04:28,319
and you can even see that at the macro

1675
01:04:33,109 --> 01:04:30,559
scale here this is a relatively

1676
01:04:35,990 --> 01:04:33,119
um unaltered

1677
01:04:38,710 --> 01:04:36,000
prototype and this is a much more

1678
01:04:40,390 --> 01:04:38,720
highly extensively altered prototype and

1679
01:04:41,829 --> 01:04:40,400
so um

1680
01:04:43,190 --> 01:04:41,839
we're going to start by looking at these

1681
01:04:45,589 --> 01:04:43,200
rocks at the bulk scale with some

1682
01:04:47,270 --> 01:04:45,599
techniques that can shed light on the

1683
01:04:49,510 --> 01:04:47,280
redox state of iron

1684
01:04:52,390 --> 01:04:49,520
in those rocks and

1685
01:04:55,750 --> 01:04:52,400
so we mainly use synchrotron radiation

1686
01:04:58,309 --> 01:04:55,760
based techniques to get at

1687
01:05:00,470 --> 01:04:58,319
mineral speciation

1688
01:05:01,750 --> 01:05:00,480

coupled to the iron oxidation state and

1689
01:05:04,710 --> 01:05:01,760
i'm going to go through some of those

1690
01:05:08,309 --> 01:05:06,309
using this fluorescence spectra we can

1691
01:05:10,230 --> 01:05:08,319
actually see a difference between the

1692
01:05:12,390 --> 01:05:10,240
green here we have olivine

1693
01:05:15,510 --> 01:05:12,400
and in red is fairy hydrite so an iron

1694
01:05:17,750 --> 01:05:15,520
two bearing an iron three bearing

1695
01:05:19,270 --> 01:05:17,760
phase with blue in the middle here being

1696
01:05:21,670 --> 01:05:19,280
serpentine and you can see that the peak

1697
01:05:23,430 --> 01:05:21,680
position changes

1698
01:05:25,349 --> 01:05:23,440
from lower to higher energy

1699
01:05:27,750 --> 01:05:25,359
depending on the

1700
01:05:29,430 --> 01:05:27,760
oxidation state of iron but this is also

1701
01:05:30,470 --> 01:05:29,440
complicated by the coordination state of

1702
01:05:34,870 --> 01:05:30,480
iron

1703
01:05:35,670 --> 01:05:34,880
being held in and so if we want to get

1704
01:05:36,630 --> 01:05:35,680
um

1705
01:05:38,150 --> 01:05:36,640
well

1706
01:05:39,109 --> 01:05:38,160
but still we can get some information

1707
01:05:42,470 --> 01:05:39,119
from this

1708
01:05:44,309 --> 01:05:42,480
and when we collect these full spectra

1709
01:05:46,630 --> 01:05:44,319
you can see that these less altered

1710
01:05:49,670 --> 01:05:46,640
rocks kind of group over here in these

1711
01:05:52,230 --> 01:05:49,680
red orange i'm sorry black and orange

1712
01:05:55,430 --> 01:05:52,240
spectra and these more altered rocks

1713
01:05:57,270 --> 01:05:55,440

make a group again at higher energy

1714
01:06:00,230 --> 01:05:57,280
in these lighter color spectra so we can

1715
01:06:03,190 --> 01:06:00,240
definitely tease apart differences um

1716
01:06:04,390 --> 01:06:03,200
but we can turn to the pre-edge down

1717
01:06:05,910 --> 01:06:04,400
here

1718
01:06:07,750 --> 01:06:05,920
of the spectra

1719
01:06:10,549 --> 01:06:07,760
which is blown up over here

1720
01:06:11,270 --> 01:06:10,559
to be more quantitative about

1721
01:06:13,109 --> 01:06:11,280
oh

1722
01:06:15,910 --> 01:06:13,119
sorry

1723
01:06:17,910 --> 01:06:15,920
um to be more quantitative um

1724
01:06:19,670 --> 01:06:17,920
about the difference between the redux

1725
01:06:20,789 --> 01:06:19,680
state in these different mineral phases

1726
01:06:22,630 --> 01:06:20,799
and so

1727
01:06:24,069 --> 01:06:22,640
um

1728
01:06:25,670 --> 01:06:24,079
this is just a blow up essentially

1729
01:06:27,990 --> 01:06:25,680
showing you

1730
01:06:29,510 --> 01:06:28,000
the difference in the pre-edge region of

1731
01:06:31,190 --> 01:06:29,520
the structure

1732
01:06:32,950 --> 01:06:31,200
and the pre-edge is more sensitive to

1733
01:06:36,230 --> 01:06:32,960
the oxidation state and the coordination

1734
01:06:39,349 --> 01:06:36,240
in a way that's actually predictable

1735
01:06:41,589 --> 01:06:39,359
and can be quantifiable

1736
01:06:43,029 --> 01:06:41,599
so

1737
01:06:45,270 --> 01:06:43,039
briefly

1738
01:06:47,270 --> 01:06:45,280

what we do is collect these stains

1739
01:06:49,430 --> 01:06:47,280
speculate on our bulk these are bulk

1740
01:06:52,230 --> 01:06:49,440
thank you samples

1741
01:06:54,630 --> 01:06:52,240
um powdered samples of the of those

1742
01:06:56,870 --> 01:06:54,640
rocks and then we background correct

1743
01:06:58,150 --> 01:06:56,880
that part of the spectrum

1744
01:07:01,029 --> 01:06:58,160
and we

1745
01:07:02,549 --> 01:07:01,039
come up figure out what the centroid of

1746
01:07:04,870 --> 01:07:02,559
that peak is

1747
01:07:05,910 --> 01:07:04,880
and the integrated intensity under that

1748
01:07:07,910 --> 01:07:05,920
peak

1749
01:07:10,470 --> 01:07:07,920
and we can plot that

1750
01:07:13,109 --> 01:07:10,480
onto a variogram and here we're really

1751
01:07:16,789 --> 01:07:13,119
building off of the work done previously

1752
01:07:18,630 --> 01:07:16,799
by max wilkie and muriel andriani and

1753
01:07:21,029 --> 01:07:18,640
and using um standards that were

1754
01:07:22,390 --> 01:07:21,039
provided to us by manuel munoz

1755
01:07:24,309 --> 01:07:22,400
um

1756
01:07:28,069 --> 01:07:24,319
to

1757
01:07:30,390 --> 01:07:28,079
the iron three

1758
01:07:31,589 --> 01:07:30,400
in our samples and so we use these

1759
01:07:34,069 --> 01:07:31,599
standards that

1760
01:07:36,549 --> 01:07:34,079
are n members of iron two

1761
01:07:39,589 --> 01:07:36,559
in six i'm sorry octahedral coordination

1762
01:07:41,589 --> 01:07:39,599
or tetrahedral coordination iron iii in

1763
01:07:43,510 --> 01:07:41,599

octahedral coordination or tetrahedral

1764
01:07:45,029 --> 01:07:43,520
coordination and then these manual

1765
01:07:46,470 --> 01:07:45,039
mixtures

1766
01:07:48,309 --> 01:07:46,480
of those

1767
01:07:50,150 --> 01:07:48,319
um

1768
01:07:51,510 --> 01:07:50,160
of those standards

1769
01:07:54,069 --> 01:07:51,520
then that can

1770
01:07:57,430 --> 01:07:54,079
that give you a quantifiable

1771
01:08:00,870 --> 01:07:57,440
sort of estimate i guess of um

1772
01:08:03,349 --> 01:08:00,880
the percent of iron iii in your

1773
01:08:04,950 --> 01:08:03,359
in your unknown sample

1774
01:08:07,829 --> 01:08:04,960
okay so

1775
01:08:09,109 --> 01:08:07,839
when we do this with our bulk oman

1776
01:08:10,390 --> 01:08:09,119
samples

1777
01:08:12,470 --> 01:08:10,400
we find two

1778
01:08:14,150 --> 01:08:12,480
separate populations which is good

1779
01:08:15,510 --> 01:08:14,160
because that's what we're seeing

1780
01:08:17,430 --> 01:08:15,520
um

1781
01:08:18,309 --> 01:08:17,440
from our other techniques as well and

1782
01:08:20,149 --> 01:08:18,319
that's

1783
01:08:22,070 --> 01:08:20,159
these less altered prototypes tend to

1784
01:08:23,349 --> 01:08:22,080
have thirty to fifty percent

1785
01:08:25,269 --> 01:08:23,359
iron three

1786
01:08:26,950 --> 01:08:25,279
whereas the more highly altered

1787
01:08:29,590 --> 01:08:26,960
prototypes that we looked at have

1788
01:08:30,470 --> 01:08:29,600

greater than eighty percent um iron

1789
01:08:32,229 --> 01:08:30,480
three

1790
01:08:34,470 --> 01:08:32,239
so there's a definite

1791
01:08:38,950 --> 01:08:34,480
difference in the oxidation state of

1792
01:08:41,829 --> 01:08:38,960
iron in these rocks on the bulk scale

1793
01:08:43,990 --> 01:08:41,839
okay but we want to know um where does

1794
01:08:45,030 --> 01:08:44,000
this iron actually reside which phases

1795
01:08:46,390 --> 01:08:45,040
are actually

1796
01:08:47,590 --> 01:08:46,400
have the iron two and which ones have

1797
01:08:50,229 --> 01:08:47,600
the iron iii

1798
01:08:51,590 --> 01:08:50,239
that's interesting um

1799
01:08:55,829 --> 01:08:51,600
and so

1800
01:08:57,910 --> 01:08:55,839
this is a chem scan map micro scale map

1801
01:09:00,630 --> 01:08:57,920
of mineralogy and one of our less

1802
01:09:02,470 --> 01:09:00,640
altered prototypes from oman and the

1803
01:09:03,829 --> 01:09:02,480
green is olivine and the brown is

1804
01:09:05,910 --> 01:09:03,839
serpentine and so you can see they're

1805
01:09:07,430 --> 01:09:05,920
already extensively

1806
01:09:09,590 --> 01:09:07,440
serpentinized

1807
01:09:12,070 --> 01:09:09,600
but there's also a lot of relic olivine

1808
01:09:13,990 --> 01:09:12,080
around

1809
01:09:16,070 --> 01:09:14,000
and that looks very different

1810
01:09:17,669 --> 01:09:16,080
from

1811
01:09:19,510 --> 01:09:17,679
one of these much more highly altered

1812
01:09:21,430 --> 01:09:19,520
rocks and this is an example of one

1813
01:09:24,149 --> 01:09:21,440

that's extensively carbonated that's in

1814
01:09:26,309 --> 01:09:24,159
purple like all of the carbonate um has

1815
01:09:28,630 --> 01:09:26,319
about the same amount of serpentine

1816
01:09:29,910 --> 01:09:28,640
um but no no olivine

1817
01:09:32,550 --> 01:09:29,920
and the pyroxenes are more highly

1818
01:09:33,669 --> 01:09:32,560
reacted so there's definite um

1819
01:09:36,149 --> 01:09:33,679
differences

1820
01:09:36,950 --> 01:09:36,159
mineralogy

1821
01:09:38,870 --> 01:09:36,960
um

1822
01:09:40,229 --> 01:09:38,880
of these two different rock types from

1823
01:09:41,749 --> 01:09:40,239
oman

1824
01:09:43,510 --> 01:09:41,759
and then we can

1825
01:09:45,189 --> 01:09:43,520
we've turned to hyperspectral raman

1826
01:09:48,550 --> 01:09:45,199
imaging to try to

1827
01:09:49,669 --> 01:09:48,560
get at the mineralogy in an even more

1828
01:09:51,910 --> 01:09:49,679
detail

1829
01:09:53,189 --> 01:09:51,920
and this has revealed things to us that

1830
01:09:54,950 --> 01:09:53,199
were

1831
01:09:56,550 --> 01:09:54,960
that we couldn't see from chem scan

1832
01:09:58,070 --> 01:09:56,560
analyses

1833
01:09:59,990 --> 01:09:58,080
for instance um

1834
01:10:02,390 --> 01:10:00,000
we find minor phases that are

1835
01:10:03,590 --> 01:10:02,400
interesting for a lot of reasons that um

1836
01:10:05,430 --> 01:10:03,600
including

1837
01:10:07,990 --> 01:10:05,440
possible carbon associations such as

1838
01:10:09,270 --> 01:10:08,000

garnet um but what i want you guys to

1839
01:10:10,149 --> 01:10:09,280
focus on

1840
01:10:12,229 --> 01:10:10,159
is

1841
01:10:15,350 --> 01:10:12,239
the serpentine and there's two different

1842
01:10:17,110 --> 01:10:15,360
serpentines one that has this extra peak

1843
01:10:18,149 --> 01:10:17,120
and one that does not and you can see

1844
01:10:20,229 --> 01:10:18,159
that they're

1845
01:10:23,430 --> 01:10:20,239
intermixed in this cyan and the dark

1846
01:10:24,630 --> 01:10:23,440
blue here in this raman mineralogy map

1847
01:10:27,110 --> 01:10:24,640
which is what's shown here and

1848
01:10:29,030 --> 01:10:27,120
corresponds to this color legend

1849
01:10:30,470 --> 01:10:29,040
um

1850
01:10:34,390 --> 01:10:30,480
so

1851
01:10:37,830 --> 01:10:35,830
and i guess i should back up and just

1852
01:10:39,830 --> 01:10:37,840
say that this map and these spectra were

1853
01:10:42,229 --> 01:10:39,840
collected within the fingerprint region

1854
01:10:44,790 --> 01:10:42,239
which is a pretty diagnostic

1855
01:10:46,550 --> 01:10:44,800
um region of a raman spectrum for

1856
01:10:47,510 --> 01:10:46,560
distinguishing between different mineral

1857
01:10:49,270 --> 01:10:47,520
types

1858
01:10:50,630 --> 01:10:49,280
um but we wanted to know more about the

1859
01:10:52,550 --> 01:10:50,640
difference between these

1860
01:10:54,709 --> 01:10:52,560
two serpentine phases

1861
01:10:56,070 --> 01:10:54,719
and so we also mapped out

1862
01:10:57,110 --> 01:10:56,080
at um

1863
01:11:00,630 --> 01:10:57,120

where the

1864
01:11:03,430 --> 01:11:00,640
o h bonds are active and

1865
01:11:04,870 --> 01:11:03,440
we actually see it a whole different

1866
01:11:05,750 --> 01:11:04,880
peak

1867
01:11:07,189 --> 01:11:05,760
um

1868
01:11:09,910 --> 01:11:07,199
that is much

1869
01:11:11,830 --> 01:11:09,920
much more intense in the areas where

1870
01:11:13,350 --> 01:11:11,840
serpentine is blue

1871
01:11:16,310 --> 01:11:13,360
and this corresponds actually to the

1872
01:11:17,990 --> 01:11:16,320
position of the oh peak in brucite

1873
01:11:19,590 --> 01:11:18,000
so using this

1874
01:11:23,110 --> 01:11:19,600
ramen technique we're able to

1875
01:11:25,990 --> 01:11:23,120
distinguish that our serpentine in red

1876
01:11:28,149 --> 01:11:26,000
is different from our serpentine in blue

1877
01:11:30,709 --> 01:11:28,159
and that one key difference seems to be

1878
01:11:33,830 --> 01:11:30,719
the presence of bruceite mixed in with

1879
01:11:37,189 --> 01:11:34,630
and

1880
01:11:39,270 --> 01:11:37,199
happily frieder

1881
01:11:41,030 --> 01:11:39,280
explained a lot about the potential

1882
01:11:42,550 --> 01:11:41,040
importance of brucite because it can

1883
01:11:44,470 --> 01:11:42,560
take up iron ii

1884
01:11:46,790 --> 01:11:44,480
um

1885
01:11:49,350 --> 01:11:46,800
and eric who is in our lab has been

1886
01:11:51,110 --> 01:11:49,360
working really hard on um coming up with

1887
01:11:53,270 --> 01:11:51,120
a method for actually being able to

1888
01:11:55,669 --> 01:11:53,280

estimate the iron content of this brew

1889
01:11:58,229 --> 01:11:55,679
site even when we can't take these

1890
01:11:59,510 --> 01:11:58,239
samples to the microprobe and make

1891
01:12:01,030 --> 01:11:59,520
individual

1892
01:12:02,550 --> 01:12:01,040
measure chemical measurements of these

1893
01:12:05,270 --> 01:12:02,560
individual phases because they're just

1894
01:12:07,590 --> 01:12:05,280
too intermixed on a micro scale

1895
01:12:10,310 --> 01:12:07,600
we can use the position

1896
01:12:13,110 --> 01:12:10,320
of that peak in the o h

1897
01:12:15,590 --> 01:12:13,120
stretch region of the raman spectrum

1898
01:12:16,709 --> 01:12:15,600
it shifts in a predictable way with iron

1899
01:12:18,790 --> 01:12:16,719
content

1900
01:12:23,830 --> 01:12:18,800
and

1901
01:12:28,310 --> 01:12:23,840
to build a calibration curve

1902
01:12:30,630 --> 01:12:28,320
of the position of that o-h peak

1903
01:12:32,630 --> 01:12:30,640
relative to the magnesium number of the

1904
01:12:34,830 --> 01:12:32,640
brucite that's intermixed

1905
01:12:37,430 --> 01:12:34,840
in that

1906
01:12:39,189 --> 01:12:37,440
serpentine that we see

1907
01:12:40,310 --> 01:12:39,199
so this has given us a window into

1908
01:12:42,310 --> 01:12:40,320
understanding

1909
01:12:45,030 --> 01:12:42,320
um how much iron might actually be in

1910
01:12:46,790 --> 01:12:45,040
these brew sites that we're finding

1911
01:12:49,030 --> 01:12:46,800
again even though they're they're really

1912
01:12:51,270 --> 01:12:49,040
closely intimately intimately intermixed

1913
01:12:55,270 --> 01:12:51,280

with serpentine

1914
01:13:00,229 --> 01:12:58,229
but again we want to know more about the

1915
01:13:03,030 --> 01:13:00,239
redox state of the iron in both the

1916
01:13:04,790 --> 01:13:03,040
serpentine and the bruce site

1917
01:13:06,390 --> 01:13:04,800
and

1918
01:13:08,709 --> 01:13:06,400
so

1919
01:13:09,990 --> 01:13:08,719
what we've done is an adapt that

1920
01:13:11,990 --> 01:13:10,000
pre-edge technique i was telling you

1921
01:13:14,870 --> 01:13:12,000
about earlier which we did on these bulk

1922
01:13:16,070 --> 01:13:14,880
spectra that we collected first for bulk

1923
01:13:18,470 --> 01:13:16,080
materials

1924
01:13:22,149 --> 01:13:18,480
we want to adapt that for

1925
01:13:24,550 --> 01:13:22,159
our map areas so going back to

1926
01:13:27,030 --> 01:13:24,560
this map here can we

1927
01:13:28,950 --> 01:13:27,040
actually figure out

1928
01:13:33,590 --> 01:13:28,960
the distribution of iron iii within

1929
01:13:37,030 --> 01:13:35,669
in their their locations

1930
01:13:39,189 --> 01:13:37,040
and so

1931
01:13:41,590 --> 01:13:39,199
what we do here we don't have access to

1932
01:13:44,470 --> 01:13:41,600
a hyperspectral mapping

1933
01:13:47,750 --> 01:13:44,480
beam line or not easy access anyways

1934
01:13:49,510 --> 01:13:47,760
so what we've done is take smaller

1935
01:13:50,790 --> 01:13:49,520
map or not smaller maps but take a

1936
01:13:52,790 --> 01:13:50,800
single map

1937
01:13:55,270 --> 01:13:52,800
okay add a number of different energies

1938
01:13:58,149 --> 01:13:55,280

throughout the pre-edge um

1939
01:14:00,470 --> 01:13:58,159
and then sort of build or fit a

1940
01:14:02,870 --> 01:14:00,480
peak to those

1941
01:14:05,350 --> 01:14:02,880
those energies and the same process that

1942
01:14:07,110 --> 01:14:05,360
we did before we background correct

1943
01:14:09,110 --> 01:14:07,120
we can then

1944
01:14:11,110 --> 01:14:09,120
calculate the centroid and the

1945
01:14:13,750 --> 01:14:11,120
integrated intensity

1946
01:14:16,950 --> 01:14:13,760
and plot this data on a variogram but

1947
01:14:18,709 --> 01:14:16,960
now instead of a few just a couple data

1948
01:14:20,470 --> 01:14:18,719
points on a variogram we actually have

1949
01:14:23,510 --> 01:14:20,480
this whole cloud

1950
01:14:26,550 --> 01:14:23,520
of data where each point corresponds to

1951
01:14:30,950 --> 01:14:26,560
a pixel in our map area

1952
01:14:37,270 --> 01:14:34,790
the spread in iron redox state um

1953
01:14:38,390 --> 01:14:37,280
represented by the different phases in

1954
01:14:39,430 --> 01:14:38,400
this map

1955
01:14:42,470 --> 01:14:39,440
and

1956
01:14:44,709 --> 01:14:42,480
we can calculate then the iron three

1957
01:14:46,229 --> 01:14:44,719
over total iron ratio for every pixel in

1958
01:14:49,669 --> 01:14:46,239
the map

1959
01:14:50,709 --> 01:14:49,679
and transpose that so that we can map

1960
01:14:52,149 --> 01:14:50,719
out

1961
01:14:54,830 --> 01:14:52,159
the

1962
01:14:56,390 --> 01:14:54,840
redox state of iron

1963
01:14:57,830 --> 01:14:56,400

onto

1964
01:15:00,550 --> 01:14:57,840
the map that essentially that map that

1965
01:15:02,310 --> 01:15:00,560
we collected and this is

1966
01:15:04,149 --> 01:15:02,320
even more information because it takes

1967
01:15:05,669 --> 01:15:04,159
into account not just

1968
01:15:07,830 --> 01:15:05,679
the iron iii

1969
01:15:09,669 --> 01:15:07,840
um percent but also the iron

1970
01:15:11,110 --> 01:15:09,679
concentration overall and so the way you

1971
01:15:12,630 --> 01:15:11,120
would look at this is

1972
01:15:14,390 --> 01:15:12,640
um

1973
01:15:15,910 --> 01:15:14,400
olivine

1974
01:15:18,630 --> 01:15:15,920
here is

1975
01:15:20,070 --> 01:15:18,640
has i more iron two in it

1976
01:15:27,110 --> 01:15:20,080
and

1977
01:15:28,709 --> 01:15:27,120
have less iron in general

1978
01:15:29,750 --> 01:15:28,719
um

1979
01:15:32,390 --> 01:15:29,760
so

1980
01:15:33,990 --> 01:15:32,400
we have learned a lot more now about

1981
01:15:35,270 --> 01:15:34,000
what this

1982
01:15:36,950 --> 01:15:35,280
the iron

1983
01:15:39,189 --> 01:15:36,960
oxidation state in our different mineral

1984
01:15:40,630 --> 01:15:39,199
phases is and how it's distributed

1985
01:15:43,510 --> 01:15:40,640
and you can see there's variation it's

1986
01:15:45,430 --> 01:15:43,520
heterogeneous within the serpentine

1987
01:15:46,550 --> 01:15:45,440
itself

1988
01:15:49,189 --> 01:15:46,560

um

1989
01:15:50,149 --> 01:15:49,199
okay so mike if you could start the

1990
01:15:51,590 --> 01:15:50,159
movie

1991
01:15:52,390 --> 01:15:51,600
what i'm going to try to explain to you

1992
01:15:54,149 --> 01:15:52,400
here and i should probably just make

1993
01:15:55,990 --> 01:15:54,159
garrett do this but

1994
01:15:58,630 --> 01:15:56,000
um is what we what we're doing in this

1995
01:16:01,110 --> 01:15:58,640
movie is actually overlaying

1996
01:16:02,709 --> 01:16:01,120
a redox map that i just the redox map

1997
01:16:05,270 --> 01:16:02,719
that i just showed you

1998
01:16:07,910 --> 01:16:05,280
with the mineralogy map because there's

1999
01:16:09,270 --> 01:16:07,920
just a lot of power in being able to say

2000
01:16:10,070 --> 01:16:09,280
okay

2001
01:16:11,590 --> 01:16:10,080
um

2002
01:16:13,910 --> 01:16:11,600
i don't know if i could click

2003
01:16:16,310 --> 01:16:13,920
or not i don't think oh yeah you can do

2004
01:16:18,630 --> 01:16:16,320
pointer oh i can okay so these if you

2005
01:16:23,270 --> 01:16:18,640
look at these red stripes here that's

2006
01:16:28,229 --> 01:16:26,870
with areas that are more oxidized

2007
01:16:31,110 --> 01:16:28,239
and the blue

2008
01:16:33,830 --> 01:16:31,120
serpentine appears to line up with areas

2009
01:16:35,669 --> 01:16:33,840
that are more reduced

2010
01:16:40,470 --> 01:16:35,679
okay i think we can go back

2011
01:16:44,709 --> 01:16:42,470
okay so serpentine the red serpentine is

2012
01:16:46,149 --> 01:16:44,719
more oxidized than the blue serpentine

2013
01:16:48,390 --> 01:16:46,159

and this makes sense

2014
01:16:49,669 --> 01:16:48,400
the blue serpentine has that bruce site

2015
01:16:51,270 --> 01:16:49,679
in it

2016
01:16:53,590 --> 01:16:51,280
which um

2017
01:16:55,590 --> 01:16:53,600
is iron two bearing and

2018
01:16:57,110 --> 01:16:55,600
and so another way that we can represent

2019
01:16:59,910 --> 01:16:57,120
this data

2020
01:17:02,310 --> 01:16:59,920
um quantifiably is um by plotting the

2021
01:17:04,149 --> 01:17:02,320
density of pixels

2022
01:17:05,750 --> 01:17:04,159
for each mineral type so we're actually

2023
01:17:07,110 --> 01:17:05,760
now comparing

2024
01:17:11,189 --> 01:17:07,120
olivine

2025
01:17:12,229 --> 01:17:11,199
different types of serpentine that we

2026
01:17:16,630 --> 01:17:12,239
see

2027
01:17:17,830 --> 01:17:16,640
shift in that peak position so anyways i

2028
01:17:19,510 --> 01:17:17,840
know that was a lot of information

2029
01:17:20,870 --> 01:17:19,520
really fast but i want to get on in the

2030
01:17:22,149 --> 01:17:20,880
last couple minutes

2031
01:17:23,110 --> 01:17:22,159
um

2032
01:17:25,189 --> 01:17:23,120
to

2033
01:17:26,709 --> 01:17:25,199
some other work that we're doing um this

2034
01:17:28,950 --> 01:17:26,719
is that same rock that we've been

2035
01:17:29,750 --> 01:17:28,960
setting in very very great detail

2036
01:17:31,350 --> 01:17:29,760
and

2037
01:17:34,070 --> 01:17:31,360
hannah miller in our lab has been

2038
01:17:35,590 --> 01:17:34,080

working to react that rock with water to

2039
01:17:37,510 --> 01:17:35,600
actually see if

2040
01:17:39,030 --> 01:17:37,520
it can make hydrogen we know there's

2041
01:17:41,350 --> 01:17:39,040
brucite in it it's iron two bearing

2042
01:17:43,510 --> 01:17:41,360
bruce site can we crush this rock up i

2043
01:17:45,910 --> 01:17:43,520
mean still has olivine in it as well

2044
01:17:47,990 --> 01:17:45,920
and can we make hydrogen at relatively

2045
01:17:50,550 --> 01:17:48,000
low temperatures

2046
01:17:51,990 --> 01:17:50,560
and we do see significant and sustained

2047
01:17:54,550 --> 01:17:52,000
hydrogen production

2048
01:17:56,630 --> 01:17:54,560
at 100 degrees c these are replicate

2049
01:17:58,709 --> 01:17:56,640
triplicate experiments

2050
01:18:00,950 --> 01:17:58,719
with different media a sea water media

2051
01:18:02,070 --> 01:18:00,960
in blue and a rain water media

2052
01:18:04,149 --> 01:18:02,080
in green

2053
01:18:06,149 --> 01:18:04,159
with hydrogen plotted on the y

2054
01:18:07,430 --> 01:18:06,159
axis here

2055
01:18:10,149 --> 01:18:07,440
and we see sustained production of

2056
01:18:12,470 --> 01:18:10,159
hydrogen over a number of months

2057
01:18:16,149 --> 01:18:12,480
so that's really cool and so we're

2058
01:18:17,350 --> 01:18:16,159
trying to then can we interpret what

2059
01:18:19,590 --> 01:18:17,360
reactions are happening that are

2060
01:18:20,950 --> 01:18:19,600
creating that leading to the production

2061
01:18:22,470 --> 01:18:20,960
of that hydrogen

2062
01:18:23,990 --> 01:18:22,480
and

2063
01:18:26,229 --> 01:18:24,000

here we can just

2064
01:18:28,310 --> 01:18:26,239
look at some relatively simple xrd

2065
01:18:30,470 --> 01:18:28,320
spectra and see that this bruce site

2066
01:18:33,110 --> 01:18:30,480
peak that exists here in the unreacted

2067
01:18:35,350 --> 01:18:33,120
material is actually missing

2068
01:18:36,550 --> 01:18:35,360
disappeared from these reacted

2069
01:18:39,110 --> 01:18:36,560
experiments

2070
01:18:41,110 --> 01:18:39,120
it seems like brucite is consumed during

2071
01:18:42,550 --> 01:18:41,120
these water rock reactions

2072
01:18:44,310 --> 01:18:42,560
which is pretty cool

2073
01:18:45,750 --> 01:18:44,320
and i'm not going to show you the

2074
01:18:47,110 --> 01:18:45,760
evidence but there's serpentine and

2075
01:18:50,550 --> 01:18:47,120
magnetite

2076
01:18:52,709 --> 01:18:50,560
that form and we'll move on here

2077
01:18:54,550 --> 01:18:52,719
but one of the big complicating factors

2078
01:18:57,350 --> 01:18:54,560
in these sorts of experiments

2079
01:18:59,990 --> 01:18:57,360
is the experimental setup

2080
01:19:02,390 --> 01:19:00,000
what i'm showing you now in this plot is

2081
01:19:06,149 --> 01:19:02,400
the concentration of silica increasing

2082
01:19:08,470 --> 01:19:06,159
with time during reaction in these glass

2083
01:19:09,590 --> 01:19:08,480
serum vials in which we're doing these

2084
01:19:12,310 --> 01:19:09,600
reactions

2085
01:19:13,270 --> 01:19:12,320
we've also documented hydrogen input and

2086
01:19:16,149 --> 01:19:13,280
loss

2087
01:19:17,110 --> 01:19:16,159
across the rubber stoppers

2088
01:19:19,430 --> 01:19:17,120

that these

2089
01:19:20,550 --> 01:19:19,440
that cap these vials so these are this

2090
01:19:22,390 --> 01:19:20,560
is like the easiest way to do these

2091
01:19:24,950 --> 01:19:22,400
experiments is in these glass vials but

2092
01:19:26,550 --> 01:19:24,960
there's a lot of complications involved

2093
01:19:29,270 --> 01:19:26,560
so a while ago we started trying to

2094
01:19:30,790 --> 01:19:29,280
figure out how to address those

2095
01:19:32,790 --> 01:19:30,800
and this has been a work in progress for

2096
01:19:35,669 --> 01:19:32,800
quite some time but um

2097
01:19:37,350 --> 01:19:35,679
we are developing a

2098
01:19:39,270 --> 01:19:37,360
a titanium

2099
01:19:41,030 --> 01:19:39,280
reaction vessel that does not have any

2100
01:19:44,550 --> 01:19:41,040
rubber or anything like that

2101
01:19:46,790 --> 01:19:44,560
um but which also allows us to

2102
01:19:49,189 --> 01:19:46,800
sample repeatedly for for gas

2103
01:19:51,590 --> 01:19:49,199
concentration without

2104
01:19:52,790 --> 01:19:51,600
contaminating the system or or leaking

2105
01:19:53,910 --> 01:19:52,800
any gas

2106
01:19:56,310 --> 01:19:53,920
um

2107
01:19:58,310 --> 01:19:56,320
or adding any gases and then

2108
01:20:00,149 --> 01:19:58,320
um also will allow us to get the fluids

2109
01:20:04,229 --> 01:20:00,159
and the minerals out of this system as

2110
01:20:05,590 --> 01:20:04,239
well and so this is a work in progress

2111
01:20:08,310 --> 01:20:05,600
okay so

2112
01:20:10,310 --> 01:20:08,320
anyways sorry to be too long but

2113
01:20:13,110 --> 01:20:10,320

this is

2114
01:20:15,910 --> 01:20:13,120
just a picture of what we all have going

2115
01:20:17,669 --> 01:20:15,920
on in the lab to push forward work um

2116
01:20:19,030 --> 01:20:17,679
both analytically and experimentally to

2117
01:20:21,030 --> 01:20:19,040
try to get at these low temperature

2118
01:20:24,070 --> 01:20:21,040
water rock reactions

2119
01:20:26,149 --> 01:20:24,080
okay uh thank you a lot lisa for uh that

2120
01:20:28,709 --> 01:20:26,159
presentation and uh

2121
01:20:30,550 --> 01:20:28,719
we are scheduled to take a break now uh

2122
01:20:35,430 --> 01:20:30,560
were there any questions that came up

2123
01:20:40,870 --> 01:20:38,709
perhaps be answered uh

2124
01:20:42,470 --> 01:20:40,880
so what time the time is now

2125
01:20:44,950 --> 01:20:42,480
11 20

2126
01:20:48,070 --> 01:20:44,960
uh we will uh

2127
01:20:50,629 --> 01:20:48,080
reconvene then at 11

2128
01:20:51,590 --> 01:20:50,639
30 and i will let

2129
01:20:58,229 --> 01:20:51,600
uh

2130
01:20:59,510 --> 01:20:58,239
she wants and those of you who want to

2131
01:21:00,870 --> 01:20:59,520
uh

2132
01:21:01,750 --> 01:21:00,880
take a break

2133
01:21:03,669 --> 01:21:01,760
uh

2134
01:21:05,510 --> 01:21:03,679
you can go ahead and do so and and lisa

2135
01:21:07,030 --> 01:21:05,520
can address the questions and if you

2136
01:21:08,070 --> 01:21:07,040
could read the questions and yeah all

2137
01:21:09,750 --> 01:21:08,080
right

2138
01:21:12,310 --> 01:21:09,760

sure um so the first is from adrian

2139
01:21:15,110 --> 01:21:12,320
brown he asks um did you find uh

2140
01:21:18,270 --> 01:21:15,120
nonternite in any of your samples

2141
01:21:20,470 --> 01:21:18,280
so adrian if you're referring to the

2142
01:21:21,910 --> 01:21:20,480
serpentinites from

2143
01:21:22,790 --> 01:21:21,920
from oman

2144
01:21:26,830 --> 01:21:22,800
no

2145
01:21:30,229 --> 01:21:26,840
experimental samples

2146
01:21:31,750 --> 01:21:30,239
uh we sometimes do find clays because

2147
01:21:35,430 --> 01:21:31,760
we're adding extra silica into the

2148
01:21:37,270 --> 01:21:35,440
system from the borosilicate glass vials

2149
01:21:40,390 --> 01:21:37,280
okay and this is a question from frieder

2150
01:21:43,189 --> 01:21:40,400
klein he asks uh lisa how do your uh

2151
01:21:46,310 --> 01:21:43,199
zayn's results x-a-n-e-s compare with

2152
01:21:49,750 --> 01:21:46,320
muriel's results and did you find any

2153
01:21:49,760 --> 01:21:52,229
um

2154
01:21:55,910 --> 01:21:54,390
i guess frieder that question of

2155
01:21:57,350 --> 01:21:55,920
how our zane's results compare with

2156
01:22:00,870 --> 01:21:57,360
muriel's

2157
01:22:03,189 --> 01:22:00,880
um i'm not quite sure how specific you

2158
01:22:04,550 --> 01:22:03,199
want me to be we're using a

2159
01:22:06,550 --> 01:22:04,560
a bit of a different approach when it

2160
01:22:08,390 --> 01:22:06,560
comes to the mapping because they have

2161
01:22:10,550 --> 01:22:08,400
access to hyperspectral mapping results

2162
01:22:12,310 --> 01:22:10,560
and we're studying different sample

2163
01:22:14,470 --> 01:22:12,320

suites but we've

2164
01:22:16,149 --> 01:22:14,480
um presented this data at serpentine

2165
01:22:19,990 --> 01:22:16,159
days and had long conversations with

2166
01:22:21,830 --> 01:22:20,000
muriel and mu and manuel munoz um

2167
01:22:22,870 --> 01:22:21,840
and i guess are sort of moving forward

2168
01:22:26,070 --> 01:22:22,880
in

2169
01:22:28,390 --> 01:22:26,080
how and

2170
01:22:30,070 --> 01:22:28,400
where and how we have discrepancies in

2171
01:22:32,149 --> 01:22:30,080
data sets that maybe don't make sense

2172
01:22:33,910 --> 01:22:32,159
and we'd like to actually cross compare

2173
01:22:37,189 --> 01:22:33,920
between data sets that they've analyzed

2174
01:22:42,310 --> 01:22:40,229
versus ours and

2175
01:22:45,750 --> 01:22:42,320
frieders says in terms of overall iron

2176
01:22:47,910 --> 01:22:45,760
iii iron total in different rock domains

2177
01:22:49,510 --> 01:22:47,920
um

2178
01:22:51,750 --> 01:22:49,520
i totally like

2179
01:22:52,870 --> 01:22:51,760
similar fields yeah

2180
01:22:58,709 --> 01:22:52,880
so

2181
01:22:59,590 --> 01:22:58,719
real similar fields in general um

2182
01:23:02,310 --> 01:22:59,600
okay

2183
01:23:06,229 --> 01:23:02,320
and then iowaite

2184
01:23:09,189 --> 01:23:06,239
uh do you want me to

2185
01:23:10,790 --> 01:23:09,199
i'll just say that that yes we do find

2186
01:23:13,110 --> 01:23:10,800
um interesting

2187
01:23:16,870 --> 01:23:13,120
indications of things like ioa or other

2188
01:23:21,270 --> 01:23:19,510

not in particular in the

2189
01:23:23,270 --> 01:23:21,280
sample that lisa was talking about

2190
01:23:24,790 --> 01:23:23,280
specifically but we

2191
01:23:26,310 --> 01:23:24,800
do find

2192
01:23:29,110 --> 01:23:26,320
those sorts of minerals and other rocks

2193
01:23:32,790 --> 01:23:30,390
okay and the last question is from

2194
01:23:34,629 --> 01:23:32,800
hector la madrid going back to the

2195
01:23:36,229 --> 01:23:34,639
serpentine one and two what is the

2196
01:23:40,870 --> 01:23:36,239
perigenesis

2197
01:23:46,070 --> 01:23:42,870
no

2198
01:23:49,669 --> 01:23:46,080
legend

2199
01:23:52,149 --> 01:23:49,679
those are unfortunately named um

2200
01:23:54,070 --> 01:23:52,159
serpentine two i believe was the

2201
01:23:56,149 --> 01:23:54,080
serpentine plus bruceite which is the

2202
01:23:57,030 --> 01:23:56,159
less oxidized

2203
01:24:00,470 --> 01:23:57,040
um

2204
01:24:05,430 --> 01:24:03,189
in terms of the perigenesis

2205
01:24:06,390 --> 01:24:05,440
um

2206
01:24:08,550 --> 01:24:06,400
yeah

2207
01:24:10,149 --> 01:24:08,560
in i mean like the different generations

2208
01:24:12,390 --> 01:24:10,159
of serpentine is one the first versus

2209
01:24:13,510 --> 01:24:12,400
the second generation of serpentine

2210
01:24:14,830 --> 01:24:13,520
um

2211
01:24:18,629 --> 01:24:14,840
because i'm not quite

2212
01:24:21,910 --> 01:24:19,750
no that's why

2213
01:24:24,149 --> 01:24:21,920

we'll let hector uh clarify his question

2214
01:24:26,870 --> 01:24:24,159
um we're laughing because her son is

2215
01:24:38,070 --> 01:24:26,880
typing in it's your two-year-old son

2216
01:24:41,990 --> 01:24:41,189
um yes sir one being first right okay so

2217
01:24:45,990 --> 01:24:42,000
the

2218
01:24:47,590 --> 01:24:46,000
and serp two don't

2219
01:24:48,629 --> 01:24:47,600
correspond to

2220
01:24:54,870 --> 01:24:48,639
the

2221
01:24:56,310 --> 01:24:54,880
generations of those serpentines and i

2222
01:24:58,070 --> 01:24:56,320
actually

2223
01:25:00,629 --> 01:24:58,080
can't speak to that right now i guess

2224
01:25:03,910 --> 01:25:00,639
i'm sorry about that

2225
01:25:05,830 --> 01:25:03,920
um okay so brian said we might have to

2226
01:25:07,030 --> 01:25:05,840
uh

2227
01:25:08,149 --> 01:25:07,040
just so we can get people to have a

2228
01:25:09,990 --> 01:25:08,159
break do you wanna maybe take these in

2229
01:25:13,030 --> 01:25:10,000
the chat and we'll uh have a quick ten

2230
01:25:14,709 --> 01:25:13,040
minute break good yeah okay um so we'll

2231
01:25:15,990 --> 01:25:14,719
see you all everybody

2232
01:25:19,030 --> 01:25:16,000
uh yeah that's all thankfully so much

2233
01:25:24,830 --> 01:25:21,590
so uh it's now 10 25 pacific we'll be

2234
01:25:27,350 --> 01:25:24,840
back at 10 35 pacific

2235
01:25:29,510 --> 01:25:27,360
time thank you very much for having me

2236
01:25:31,510 --> 01:25:29,520
and thank you tom for inviting me to be

2237
01:25:34,070 --> 01:25:31,520
a speaker here i'm very grateful also

2238
01:25:36,470 --> 01:25:34,080

for tori and jen to organize this uh

2239
01:25:39,189 --> 01:25:36,480
workshop and a big shout out to alexis

2240
01:25:41,350 --> 01:25:39,199
for organizing this cohort of serpent

2241
01:25:42,790 --> 01:25:41,360
serpentine enthusiasts

2242
01:25:44,709 --> 01:25:42,800
um so if you don't know me my name is

2243
01:25:47,030 --> 01:25:44,719
sandra i'm a research scientist with

2244
01:25:48,229 --> 01:25:47,040
bmsis and i'm working at nasa ames and

2245
01:25:50,390 --> 01:25:48,239
torres group

2246
01:25:53,189 --> 01:25:50,400
and the title of my talk is a biological

2247
01:25:55,669 --> 01:25:53,199
potential of serpentinizing systems it's

2248
01:25:57,590 --> 01:25:55,679
a title that you it's quite similar to

2249
01:25:58,550 --> 01:25:57,600
everett's talk yesterday and for good

2250
01:26:00,790 --> 01:25:58,560
reason

2251
01:26:02,629 --> 01:26:00,800
we use a complementary approaches to

2252
01:26:04,390 --> 01:26:02,639
kind of the understand the big question

2253
01:26:06,790 --> 01:26:04,400
of how to link

2254
01:26:08,550 --> 01:26:06,800
microbiology and geochemistry so how

2255
01:26:10,550 --> 01:26:08,560
does one actually do that everett kind

2256
01:26:12,950 --> 01:26:10,560
of gave the answer yesterday

2257
01:26:15,990 --> 01:26:12,960
and that is through energy

2258
01:26:18,550 --> 01:26:16,000
so rocks and water and heats are the

2259
01:26:20,709 --> 01:26:18,560
source of energy then that biology

2260
01:26:22,709 --> 01:26:20,719
consumes so you can describe this water

2261
01:26:26,229 --> 01:26:22,719
rock reaction in terms of jewels and you

2262
01:26:28,629 --> 01:26:26,239
can describe the biology's use

2263
01:26:30,790 --> 01:26:28,639

of what the water and the rock puts out

2264
01:26:32,870 --> 01:26:30,800
also in terms of jewels

2265
01:26:34,950 --> 01:26:32,880
and so energy is linked

2266
01:26:36,470 --> 01:26:34,960
quite a bit to habitability which is why

2267
01:26:37,669 --> 01:26:36,480
we're interested in this in the first

2268
01:26:39,830 --> 01:26:37,679
place

2269
01:26:42,390 --> 01:26:39,840
and uh so the next question is then how

2270
01:26:44,629 --> 01:26:42,400
does one quantify this concept of

2271
01:26:46,709 --> 01:26:44,639
habitability and different people have

2272
01:26:48,550 --> 01:26:46,719
quantified it differently uh carol

2273
01:26:50,550 --> 01:26:48,560
stalker has a definition

2274
01:26:52,870 --> 01:26:50,560
derek schulze makush has another one

2275
01:26:53,910 --> 01:26:52,880
everett uh also has another another one

2276
01:26:56,070 --> 01:26:53,920
through uh

2277
01:26:58,790 --> 01:26:56,080
shotgun holland 2007 paper

2278
01:26:59,910 --> 01:26:58,800
and tori through his 2004 2007 papers

2279
01:27:02,149 --> 01:26:59,920
also has

2280
01:27:03,430 --> 01:27:02,159
his uh his take on it and of course

2281
01:27:05,189 --> 01:27:03,440
being a little bit advised towards this

2282
01:27:07,750 --> 01:27:05,199
the latter one is what i'm going to be

2283
01:27:09,510 --> 01:27:07,760
uh talking about i'll give the answer

2284
01:27:12,229 --> 01:27:09,520
and how does one actually quantify this

2285
01:27:15,270 --> 01:27:12,239
concept of habitability in two slides

2286
01:27:17,590 --> 01:27:15,280
but first i want to uh

2287
01:27:20,070 --> 01:27:17,600
define a few

2288
01:27:26,229 --> 01:27:23,990

i think there's a slide missing there um

2289
01:27:28,149 --> 01:27:26,239
but uh what i want to do is okay so

2290
01:27:31,590 --> 01:27:28,159
let's let's just let's just wing it and

2291
01:27:33,110 --> 01:27:31,600
and in order to to first understand how

2292
01:27:35,110 --> 01:27:33,120
this quantification is done i want you

2293
01:27:36,950 --> 01:27:35,120
to kind of

2294
01:27:39,750 --> 01:27:36,960
take the analogy of an electrical

2295
01:27:41,669 --> 01:27:39,760
circuit and apply it to a biological

2296
01:27:43,990 --> 01:27:41,679
cell so you'll you'll see

2297
01:27:45,510 --> 01:27:44,000
in the in the parenthesis under my cell

2298
01:27:47,189 --> 01:27:45,520
i've just said a

2299
01:27:48,950 --> 01:27:47,199
it's it's ambiguous for a reason it

2300
01:27:51,910 --> 01:27:48,960
could be a photovoltaic cell it could be

2301
01:27:53,669 --> 01:27:51,920
a biological cell because the analogy is

2302
01:27:54,550 --> 01:27:53,679
quite good so on the left column you

2303
01:27:56,870 --> 01:27:54,560
have

2304
01:27:59,270 --> 01:27:56,880
the properties of an electrical circuit

2305
01:28:00,709 --> 01:27:59,280
and on the right column is properties

2306
01:28:04,310 --> 01:28:00,719
the corresponding properties of a

2307
01:28:07,110 --> 01:28:04,320
biological cell so they both use energy

2308
01:28:08,950 --> 01:28:07,120
right solar geothermal

2309
01:28:10,790 --> 01:28:08,960
nuclear to that if you wanted if you're

2310
01:28:12,709 --> 01:28:10,800
talking about a

2311
01:28:15,910 --> 01:28:12,719
electrical circuit in particular the use

2312
01:28:18,950 --> 01:28:15,920
of that energy is in this case light on

2313
01:28:21,590 --> 01:28:18,960

the biological side is biosynthesis of

2314
01:28:24,310 --> 01:28:21,600
course and you can describe this this

2315
01:28:25,270 --> 01:28:24,320
cell using using electrical properties

2316
01:28:28,790 --> 01:28:25,280
such as

2317
01:28:31,510 --> 01:28:28,800
voltage as well as currents and uh the

2318
01:28:33,830 --> 01:28:31,520
analogy in the biological world is that

2319
01:28:35,910 --> 01:28:33,840
gives free energy so that's the affinity

2320
01:28:38,229 --> 01:28:35,920
that everett was talking about yesterday

2321
01:28:39,510 --> 01:28:38,239
think of it as a chemical voltage

2322
01:28:42,229 --> 01:28:39,520
and uh the

2323
01:28:43,830 --> 01:28:42,239
flux of electron the current is the flux

2324
01:28:46,790 --> 01:28:43,840
of substrate which are carrying the

2325
01:28:48,950 --> 01:28:46,800
electrons into into the cell of course

2326
01:28:51,110 --> 01:28:48,960
redox reactions are essentially a

2327
01:28:53,110 --> 01:28:51,120
electron transferring reaction so the

2328
01:28:54,229 --> 01:28:53,120
analogy holds there

2329
01:28:56,870 --> 01:28:54,239
as well

2330
01:28:58,310 --> 01:28:56,880
so um

2331
01:29:00,229 --> 01:28:58,320
let's see here are the keywords that i

2332
01:29:02,470 --> 01:29:00,239
wanted to make sure we are on the same

2333
01:29:04,550 --> 01:29:02,480
page because i'm going to be using them

2334
01:29:06,790 --> 01:29:04,560
quite a bit the first one is the concept

2335
01:29:09,270 --> 01:29:06,800
of maintenance energy

2336
01:29:12,070 --> 01:29:09,280
so it's defined as the energy required

2337
01:29:14,229 --> 01:29:12,080
by biology to maintain status quo as in

2338
01:29:16,310 --> 01:29:14,239

no growth in other words it's the energy

2339
01:29:17,830 --> 01:29:16,320
needed by biology to fix what the

2340
01:29:20,149 --> 01:29:17,840
environment breaks

2341
01:29:22,070 --> 01:29:20,159
so you can kind of see that it's it's

2342
01:29:24,550 --> 01:29:22,080
related to temperature the higher

2343
01:29:25,830 --> 01:29:24,560
temperature of the environment the more

2344
01:29:27,750 --> 01:29:25,840
you know work

2345
01:29:29,510 --> 01:29:27,760
a cell will have to do to to keep the

2346
01:29:31,030 --> 01:29:29,520
house in order

2347
01:29:33,270 --> 01:29:31,040
the next concept of course is the gibbs

2348
01:29:35,669 --> 01:29:33,280
free energy against whatever yesterday

2349
01:29:37,750 --> 01:29:35,679
called affinity it's the energy made

2350
01:29:39,669 --> 01:29:37,760
available by the environment that can be

2351
01:29:41,669 --> 01:29:39,679
harnessed by biology to do work and

2352
01:29:43,430 --> 01:29:41,679
that's important because

2353
01:29:45,750 --> 01:29:43,440
the environment supplies a bunch of

2354
01:29:48,229 --> 01:29:45,760
energy much of which cannot be harnessed

2355
01:29:51,110 --> 01:29:48,239
by biology think of it as think of the

2356
01:29:53,350 --> 01:29:51,120
heat for example the geothermal

2357
01:29:55,350 --> 01:29:53,360
so one way to to to frame it in your

2358
01:29:56,950 --> 01:29:55,360
mind with the analogy of the electrical

2359
01:29:58,629 --> 01:29:56,960
circuit is you can think of gibbs free

2360
01:30:00,629 --> 01:29:58,639
energy as that as a

2361
01:30:02,149 --> 01:30:00,639
chemical voltage

2362
01:30:05,270 --> 01:30:02,159
of a system

2363
01:30:06,790 --> 01:30:05,280

and uh i define here a concept that

2364
01:30:09,830 --> 01:30:06,800
that tory has defined as the

2365
01:30:13,030 --> 01:30:09,840
habitability index it's a ratio of the

2366
01:30:14,790 --> 01:30:13,040
energy consumed by biology over that

2367
01:30:18,149 --> 01:30:14,800
that maintenance

2368
01:30:19,990 --> 01:30:18,159
so if that ratio is greater than one

2369
01:30:21,030 --> 01:30:20,000
then we can define the environment as

2370
01:30:23,590 --> 01:30:21,040
habitable

2371
01:30:25,990 --> 01:30:23,600
if that ratio equals one

2372
01:30:28,229 --> 01:30:26,000
you're you're essentially getting from

2373
01:30:30,790 --> 01:30:28,239
the environment as much as energy as you

2374
01:30:33,590 --> 01:30:30,800
need to maintain yourself

2375
01:30:35,189 --> 01:30:33,600
and so you're habitable but clearly and

2376
01:30:37,189 --> 01:30:35,199
the low one

2377
01:30:38,470 --> 01:30:37,199
energetically you're considered not

2378
01:30:40,870 --> 01:30:38,480
habitability so that's kind of the

2379
01:30:43,430 --> 01:30:40,880
framework that will that will uh that

2380
01:30:44,870 --> 01:30:43,440
will work around

2381
01:30:45,910 --> 01:30:44,880
and so

2382
01:30:49,270 --> 01:30:45,920
the

2383
01:30:51,430 --> 01:30:49,280
methanogenesis provides this great

2384
01:30:53,590 --> 01:30:51,440
laboratory to study this link between

2385
01:30:55,590 --> 01:30:53,600
biology and geology

2386
01:30:58,070 --> 01:30:55,600
through

2387
01:31:00,870 --> 01:30:58,080
focusing on methanogenesis

2388
01:31:03,750 --> 01:31:00,880

because as we've learned this week

2389
01:31:04,750 --> 01:31:03,760
serpentinization produces hydrogen

2390
01:31:06,310 --> 01:31:04,760
and

2391
01:31:08,790 --> 01:31:06,320
methamogenesis

2392
01:31:10,790 --> 01:31:08,800
consumes this hydrogen so you can make

2393
01:31:12,470 --> 01:31:10,800
that link between geology and biology

2394
01:31:14,390 --> 01:31:12,480
through hydrogen

2395
01:31:16,790 --> 01:31:14,400
so what has been done

2396
01:31:20,070 --> 01:31:16,800
in the past to try and quantify this the

2397
01:31:22,470 --> 01:31:20,080
energetical potential of springs

2398
01:31:24,790 --> 01:31:22,480
is a calculate that gives free energy so

2399
01:31:25,590 --> 01:31:24,800
on the each row is a different spring

2400
01:31:27,910 --> 01:31:25,600
here

2401
01:31:29,510 --> 01:31:27,920
and the first three are velocity how the

2402
01:31:32,390 --> 01:31:29,520
turbolet

2403
01:31:35,430 --> 01:31:32,400
and on each column is a different uh

2404
01:31:38,229 --> 01:31:35,440
property of of that of that spring so

2405
01:31:41,110 --> 01:31:38,239
you have hydrogen ph d ic and so on and

2406
01:31:42,709 --> 01:31:41,120
you can calculate a delta g right a

2407
01:31:45,030 --> 01:31:42,719
chemical voltage

2408
01:31:47,189 --> 01:31:45,040
if you will of of those springs and then

2409
01:31:48,950 --> 01:31:47,199
look at the different metabolisms like

2410
01:31:50,310 --> 01:31:48,960
everett talked about yesterday and see

2411
01:31:52,950 --> 01:31:50,320
which ones

2412
01:31:54,790 --> 01:31:52,960
are energetically favorable

2413
01:31:56,870 --> 01:31:54,800

but you can take a bigger picture you

2414
01:31:59,110 --> 01:31:56,880
have take this table put in a larger

2415
01:32:01,590 --> 01:31:59,120
scope so what i've done here is taken

2416
01:32:04,310 --> 01:32:01,600
hydrogen on the on the y-axis which is

2417
01:32:05,510 --> 01:32:04,320
flat in this case and uh ph on the

2418
01:32:08,310 --> 01:32:05,520
x-axis

2419
01:32:11,270 --> 01:32:08,320
and plotted uh that delta g that gives

2420
01:32:13,350 --> 01:32:11,280
you energy on the on the z-axis

2421
01:32:15,270 --> 01:32:13,360
i didn't necessarily have to do it in 3d

2422
01:32:17,030 --> 01:32:15,280
but i really enjoyed plotting don't

2423
01:32:18,709 --> 01:32:17,040
judge me and so this is why it's like

2424
01:32:20,390 --> 01:32:18,719
this

2425
01:32:22,229 --> 01:32:20,400
and so uh

2426
01:32:24,229 --> 01:32:22,239
one thing to remember about delta g is

2427
01:32:25,990 --> 01:32:24,239
that there's the negative delta g that

2428
01:32:28,390 --> 01:32:26,000
we are interested in so that's the good

2429
01:32:31,110 --> 01:32:28,400
voltage right so anything that's uh

2430
01:32:33,910 --> 01:32:31,120
higher than minus 10 minus 10

2431
01:32:36,149 --> 01:32:33,920
is roughly the the it's the kind of the

2432
01:32:38,830 --> 01:32:36,159
minimum threshold to run atp so the

2433
01:32:41,350 --> 01:32:38,840
voltage you need to apply to to run

2434
01:32:43,590 --> 01:32:41,360
atp and so anything that's higher than

2435
01:32:46,790 --> 01:32:43,600
that that's kind of the yellowish red in

2436
01:32:48,390 --> 01:32:46,800
this plot is is def you can see

2437
01:32:49,830 --> 01:32:48,400
if i kind of

2438
01:32:52,390 --> 01:32:49,840

roughly

2439
01:32:54,950 --> 01:32:52,400
show the location of the physical

2440
01:32:56,550 --> 01:32:54,960
chemical space of lost city or in here

2441
01:32:59,030 --> 01:32:56,560
and you can see that delta g respective

2442
01:33:02,070 --> 01:32:59,040
ph doesn't change very much

2443
01:33:04,950 --> 01:33:02,080
and it's kind of moderately uh affected

2444
01:33:08,149 --> 01:33:04,960
by by by change of hydrogen so

2445
01:33:10,550 --> 01:33:08,159
so delta g is a great way to kind of

2446
01:33:11,990 --> 01:33:10,560
scan the landscape quickly but doesn't

2447
01:33:13,510 --> 01:33:12,000
really give you a kind of a high

2448
01:33:14,870 --> 01:33:13,520
resolution to

2449
01:33:16,550 --> 01:33:14,880
to understand

2450
01:33:18,629 --> 01:33:16,560
whether or not an environment is really

2451
01:33:20,550 --> 01:33:18,639
habitable for particular metabolism

2452
01:33:22,950 --> 01:33:20,560
because it doesn't take into account the

2453
01:33:25,510 --> 01:33:22,960
energy needed to survive in that

2454
01:33:27,350 --> 01:33:25,520
environment in the first place

2455
01:33:29,910 --> 01:33:27,360
so that's where this habitability index

2456
01:33:34,709 --> 01:33:29,920
comes comes in handy

2457
01:33:38,709 --> 01:33:36,629
so if you look at the uh

2458
01:33:41,189 --> 01:33:38,719
again returning to our uh to our uh

2459
01:33:43,350 --> 01:33:41,199
analogy here we've been focusing on the

2460
01:33:45,270 --> 01:33:43,360
last two the electrical properties the

2461
01:33:47,990 --> 01:33:45,280
voltage again is that gibbs free energy

2462
01:33:49,990 --> 01:33:48,000
that we can be easily calculated

2463
01:33:51,350 --> 01:33:50,000

and uh but you know if you if you

2464
01:33:53,430 --> 01:33:51,360
measure just the voltage in an

2465
01:33:54,709 --> 01:33:53,440
electrical circuit you you could tell

2466
01:33:56,390 --> 01:33:54,719
that there was something there like a

2467
01:33:58,390 --> 01:33:56,400
light bulb but you wouldn't be able to

2468
01:34:00,950 --> 01:33:58,400
tell if it's a 60 watt light bulb or 100

2469
01:34:03,270 --> 01:34:00,960
watt light bulb 120 watt light bulb but

2470
01:34:05,189 --> 01:34:03,280
if you're able to measure the current

2471
01:34:06,629 --> 01:34:05,199
then the product of the current and the

2472
01:34:07,669 --> 01:34:06,639
voltage is the power

2473
01:34:10,390 --> 01:34:07,679
and so then you can be a lot more

2474
01:34:12,950 --> 01:34:10,400
specific about what's going on

2475
01:34:15,590 --> 01:34:12,960
and so how do you then calculate this

2476
01:34:17,189 --> 01:34:15,600
this this current this flux of substrate

2477
01:34:20,070 --> 01:34:17,199
in a uh in a

2478
01:34:21,910 --> 01:34:20,080
biological system well we can imagine if

2479
01:34:23,110 --> 01:34:21,920
this biological cell this time was

2480
01:34:24,550 --> 01:34:23,120
sitting in

2481
01:34:26,390 --> 01:34:24,560
and was eating it

2482
01:34:28,470 --> 01:34:26,400
there would be a gradient in yumminess

2483
01:34:29,910 --> 01:34:28,480
between the exterior and the interior of

2484
01:34:32,149 --> 01:34:29,920
the cell right it's a highly technical

2485
01:34:34,950 --> 01:34:32,159
term i hope you're following

2486
01:34:36,870 --> 01:34:34,960
and so this gradient you can you can

2487
01:34:38,629 --> 01:34:36,880
quantify it mathematically as the

2488
01:34:39,750 --> 01:34:38,639

diffusion of the substrate from the

2489
01:34:42,149 --> 01:34:39,760
outside

2490
01:34:45,030 --> 01:34:42,159
to the inside and uh interested in the

2491
01:34:48,310 --> 01:34:45,040
details of this uh i'll refer you to the

2492
01:34:49,750 --> 01:34:48,320
magnus opus of alperin and holo 2009

2493
01:34:52,950 --> 01:34:49,760
but essentially can you think of the

2494
01:34:55,669 --> 01:34:52,960
cell as as as

2495
01:34:57,590 --> 01:34:55,679
as a sink to the substrate and so the

2496
01:34:59,830 --> 01:34:57,600
biology brings in

2497
01:35:02,149 --> 01:34:59,840
the substrate from the outside to

2498
01:35:04,550 --> 01:35:02,159
consume it creating this this gradient

2499
01:35:06,149 --> 01:35:04,560
so in numerical space um what this means

2500
01:35:07,030 --> 01:35:06,159
so for those of you who are not familiar

2501
01:35:08,550 --> 01:35:07,040
with

2502
01:35:10,149 --> 01:35:08,560
numerical models essentially it's

2503
01:35:12,310 --> 01:35:10,159
discrete points

2504
01:35:15,030 --> 01:35:12,320
in space so in this particular

2505
01:35:18,790 --> 01:35:15,040
particular example i have um

2506
01:35:20,790 --> 01:35:18,800
i have nine points that define the

2507
01:35:22,470 --> 01:35:20,800
defined area

2508
01:35:25,270 --> 01:35:22,480
from the inside of the center of the

2509
01:35:26,950 --> 01:35:25,280
cell to the outer cell and for each

2510
01:35:28,390 --> 01:35:26,960
point i can calculate

2511
01:35:30,790 --> 01:35:28,400
this this this

2512
01:35:33,750 --> 01:35:30,800
diffusion of the substrate of interest

2513
01:35:35,910 --> 01:35:33,760

so in this case let's say it's co2

2514
01:35:38,470 --> 01:35:35,920
and so oh there's some

2515
01:35:40,709 --> 01:35:38,480
stuff missing there

2516
01:35:43,030 --> 01:35:40,719
so some equations have disappeared there

2517
01:35:45,030 --> 01:35:43,040
i'm sorry but the the equation one what

2518
01:35:47,510 --> 01:35:45,040
it is is that delta g

2519
01:35:49,109 --> 01:35:47,520
it's this uh this this chemical voltage

2520
01:35:50,390 --> 01:35:49,119
that we know how to calculate and

2521
01:35:52,709 --> 01:35:50,400
equation two

2522
01:35:56,470 --> 01:35:52,719
is uh is the rate so you can calculate

2523
01:35:58,709 --> 01:35:56,480
the the rate of uh consumption of co2 by

2524
01:36:01,030 --> 01:35:58,719
making some assumptions about the the

2525
01:36:03,669 --> 01:36:01,040
hungriness should i say of the cell

2526
01:36:05,350 --> 01:36:03,679
so this in terms of

2527
01:36:07,189 --> 01:36:05,360
of

2528
01:36:09,430 --> 01:36:07,199
metabolisms and thinking about enzymes

2529
01:36:11,270 --> 01:36:09,440
is that the vmax and km that you find in

2530
01:36:13,430 --> 01:36:11,280
enzyme kinetics so

2531
01:36:15,990 --> 01:36:13,440
applying this this

2532
01:36:17,910 --> 01:36:16,000
michaelis-menten enzymatic kinetics to

2533
01:36:19,669 --> 01:36:17,920
metabolism is something called

2534
01:36:21,189 --> 01:36:19,679
monokinetics the equation should be

2535
01:36:22,390 --> 01:36:21,199
there i'm sorry that it's not

2536
01:36:25,510 --> 01:36:22,400
and you can relate that to the

2537
01:36:27,830 --> 01:36:25,520
concentration of co2 so if you multiply

2538
01:36:29,590 --> 01:36:27,840

these two together at each of these

2539
01:36:31,750 --> 01:36:29,600
individual points

2540
01:36:32,950 --> 01:36:31,760
you get a power right you get a current

2541
01:36:34,229 --> 01:36:32,960
and a

2542
01:36:36,629 --> 01:36:34,239
voltage and you multiply the two

2543
01:36:38,950 --> 01:36:36,639
together you get a power and then

2544
01:36:40,390 --> 01:36:38,960
if you have a 1d model you would add up

2545
01:36:42,470 --> 01:36:40,400
all the powers at a different grid

2546
01:36:44,390 --> 01:36:42,480
points but since we're interested in

2547
01:36:46,470 --> 01:36:44,400
a 3d

2548
01:36:48,310 --> 01:36:46,480
cell you integrate over the volume of

2549
01:36:49,350 --> 01:36:48,320
the sphere and that gives you the

2550
01:36:51,109 --> 01:36:49,360
power

2551
01:36:51,830 --> 01:36:51,119
of the cell or you can think of it as

2552
01:36:55,350 --> 01:36:51,840
the

2553
01:36:57,189 --> 01:36:55,360
methane which is

2554
01:37:00,070 --> 01:36:57,199
the same thing as sorry the energy

2555
01:37:01,350 --> 01:37:00,080
consumed by the production of co2

2556
01:37:05,109 --> 01:37:01,360
which is the same thing as the energy

2557
01:37:08,790 --> 01:37:07,270
i had energy consumed anyways you get

2558
01:37:11,189 --> 01:37:08,800
the idea it's the the

2559
01:37:12,550 --> 01:37:11,199
the power is the important parameter

2560
01:37:14,390 --> 01:37:12,560
here

2561
01:37:16,229 --> 01:37:14,400
and so um

2562
01:37:17,669 --> 01:37:16,239
you can add a column

2563
01:37:19,750 --> 01:37:17,679

to the table

2564
01:37:22,550 --> 01:37:19,760
that i showed earlier i'm just using the

2565
01:37:24,149 --> 01:37:22,560
first three

2566
01:37:26,070 --> 01:37:24,159
springs

2567
01:37:28,470 --> 01:37:26,080
and so on the top right you have again

2568
01:37:31,590 --> 01:37:28,480
that delta g that voltage

2569
01:37:33,350 --> 01:37:31,600
and then on the on the table at the sec

2570
01:37:35,109 --> 01:37:33,360
on the lower half

2571
01:37:36,310 --> 01:37:35,119
you have you can calculate the power

2572
01:37:40,310 --> 01:37:36,320
generated

2573
01:37:41,109 --> 01:37:40,320
um from the this this modeling approach

2574
01:37:43,109 --> 01:37:41,119
and

2575
01:37:45,189 --> 01:37:43,119
you can under on the column after that

2576
01:37:47,030 --> 01:37:45,199
you have that that power demand which is

2577
01:37:48,790 --> 01:37:47,040
that maintenance which is simply an

2578
01:37:50,470 --> 01:37:48,800
arrhenius relationship

2579
01:37:52,550 --> 01:37:50,480
uh that is a function of temperature

2580
01:37:53,590 --> 01:37:52,560
there's our that relationship is lab

2581
01:37:55,910 --> 01:37:53,600
based

2582
01:37:57,830 --> 01:37:55,920
and so uh it's it's best we can do for

2583
01:37:59,510 --> 01:37:57,840
now but it's definitely a big

2584
01:38:01,990 --> 01:37:59,520
gap in knowledge and how to really

2585
01:38:02,950 --> 01:38:02,000
understand what that minimum maintenance

2586
01:38:04,390 --> 01:38:02,960
is

2587
01:38:06,790 --> 01:38:04,400
for a

2588
01:38:08,629 --> 01:38:06,800

particular cell in the

2589
01:38:10,629 --> 01:38:08,639
natural environment and so if you take

2590
01:38:12,629 --> 01:38:10,639
the ratio you can see here that it's

2591
01:38:14,709 --> 01:38:12,639
quite interesting um

2592
01:38:16,709 --> 01:38:14,719
because it gives you an assessment of

2593
01:38:18,870 --> 01:38:16,719
habitability that did not exist

2594
01:38:20,629 --> 01:38:18,880
when considering only the delta g so if

2595
01:38:23,510 --> 01:38:20,639
you look at uh

2596
01:38:25,990 --> 01:38:23,520
lchf b you'll see a negative a delta g

2597
01:38:27,030 --> 01:38:26,000
of negative 55 which in principle should

2598
01:38:28,830 --> 01:38:27,040
be good

2599
01:38:31,350 --> 01:38:28,840
for for biology from a voltage

2600
01:38:32,950 --> 01:38:31,360
perspective but when you include the

2601
01:38:34,629 --> 01:38:32,960
power

2602
01:38:38,390 --> 01:38:34,639
you see that the habitability index is

2603
01:38:40,550 --> 01:38:38,400
in fact less than one at 0.007

2604
01:38:43,750 --> 01:38:40,560
and so what this means is that in fact

2605
01:38:45,270 --> 01:38:43,760
for a metabolism of methanogenesis that

2606
01:38:46,870 --> 01:38:45,280
uses uh

2607
01:38:48,629 --> 01:38:46,880
co2

2608
01:38:50,709 --> 01:38:48,639
then it's actually not happy there at

2609
01:38:52,870 --> 01:38:50,719
all and the reason is is because if you

2610
01:38:54,870 --> 01:38:52,880
look at the temperature of that lthfv

2611
01:38:57,350 --> 01:38:54,880
you see that it's at 91 degrees so and

2612
01:38:59,189 --> 01:38:57,360
so the maintenance energy is quite high

2613
01:39:01,109 --> 01:38:59,199

at this point so the energy you receive

2614
01:39:03,109 --> 01:39:01,119
from the environment does not compensate

2615
01:39:05,350 --> 01:39:03,119
for the energy that you need to just

2616
01:39:07,750 --> 01:39:05,360
stay alive

2617
01:39:10,470 --> 01:39:07,760
so so that's cool so that's one way to

2618
01:39:13,910 --> 01:39:10,480
use this this kind of power concept is

2619
01:39:15,910 --> 01:39:13,920
to add a column essentially to spring

2620
01:39:17,910 --> 01:39:15,920
geochemical data

2621
01:39:20,229 --> 01:39:17,920
another way is to kind of link

2622
01:39:22,950 --> 01:39:20,239
geochemical models to predict hydrogen

2623
01:39:25,750 --> 01:39:22,960
given a water to rock reaction

2624
01:39:28,229 --> 01:39:25,760
using software like eq36

2625
01:39:29,430 --> 01:39:28,239
i started off using geochemist workbench

2626
01:39:32,310 --> 01:39:29,440
gwb

2627
01:39:34,629 --> 01:39:32,320
but uh it actually doesn't include iron

2628
01:39:36,709 --> 01:39:34,639
brew sites nor does it do solid

2629
01:39:39,109 --> 01:39:36,719
solutions so it's actually uh

2630
01:39:41,990 --> 01:39:39,119
it's not ideal to study serpentinization

2631
01:39:43,830 --> 01:39:42,000
reactions so here's why eq 36

2632
01:39:45,270 --> 01:39:43,840
is better for that

2633
01:39:46,709 --> 01:39:45,280
and

2634
01:39:49,430 --> 01:39:46,719
so you can link

2635
01:39:50,790 --> 01:39:49,440
eq36 with these these models of

2636
01:39:53,109 --> 01:39:50,800
bioenergy and

2637
01:39:54,470 --> 01:39:53,119
kind of explore the physical chemical

2638
01:39:56,950 --> 01:39:54,480

landscape

2639
01:39:58,149 --> 01:39:56,960
of this habitability

2640
01:40:00,470 --> 01:39:58,159
so uh

2641
01:40:01,990 --> 01:40:00,480
one has to be careful when doing that

2642
01:40:04,310 --> 01:40:02,000
because uh

2643
01:40:06,149 --> 01:40:04,320
the membrane is actually very important

2644
01:40:09,189 --> 01:40:06,159
in how it transports different

2645
01:40:11,750 --> 01:40:09,199
substrates into the cell

2646
01:40:13,510 --> 01:40:11,760
so if you look at the the

2647
01:40:15,669 --> 01:40:13,520
equation on the left the metabolic

2648
01:40:17,350 --> 01:40:15,679
equation on the left so co2 plus 4h2

2649
01:40:19,750 --> 01:40:17,360
those are kind of neutral species that

2650
01:40:21,669 --> 01:40:19,760
kind of diffuse through the membrane

2651
01:40:23,270 --> 01:40:21,679
right so that means the entire surface

2652
01:40:26,390 --> 01:40:23,280
area of the cell

2653
01:40:27,910 --> 01:40:26,400
is open to the transport of hydrogen co2

2654
01:40:29,830 --> 01:40:27,920
because there are very small molecules

2655
01:40:31,990 --> 01:40:29,840
just diffuse through

2656
01:40:33,830 --> 01:40:32,000
but if you look at methanogenesis that

2657
01:40:34,790 --> 01:40:33,840
uses bicarbonates

2658
01:40:37,109 --> 01:40:34,800
then

2659
01:40:39,270 --> 01:40:37,119
bicarbonate that does not cannot just

2660
01:40:42,310 --> 01:40:39,280
diffuse through the cell it goes into

2661
01:40:44,470 --> 01:40:42,320
the cell using ion channels which are

2662
01:40:46,870 --> 01:40:44,480
called porins and so you have to take

2663
01:40:50,070 --> 01:40:46,880

that into account when quantifying the

2664
01:40:51,910 --> 01:40:50,080
diffusion of the substrate into a cell

2665
01:40:55,030 --> 01:40:51,920
so this is what a

2666
01:40:57,270 --> 01:40:55,040
porin kind of looks like it's a protein

2667
01:40:58,310 --> 01:40:57,280
which has like channels inside it that

2668
01:41:01,669 --> 01:40:58,320
allows

2669
01:41:03,430 --> 01:41:01,679
a transport of these uh these ions into

2670
01:41:05,510 --> 01:41:03,440
the cell billy i hope you're proud of me

2671
01:41:08,310 --> 01:41:05,520
that i have a presentation where i cite

2672
01:41:10,070 --> 01:41:08,320
the broc biology of microorganisms

2673
01:41:13,270 --> 01:41:10,080
and so you can use these these

2674
01:41:14,629 --> 01:41:13,280
parameterizations to kind of

2675
01:41:16,470 --> 01:41:14,639
change i guess the diffusivity

2676
01:41:17,430 --> 01:41:16,480
coefficient of the membrane so in this

2677
01:41:18,950 --> 01:41:17,440
case

2678
01:41:21,430 --> 01:41:18,960
because

2679
01:41:23,750 --> 01:41:21,440
uh only 0.75

2680
01:41:26,149 --> 01:41:23,760
of the cell surface is actually open to

2681
01:41:28,070 --> 01:41:26,159
the transport of these ion channels the

2682
01:41:30,830 --> 01:41:28,080
way i address this numerically is just

2683
01:41:33,430 --> 01:41:30,840
dial down the diffusivity of the

2684
01:41:35,350 --> 01:41:33,440
membrane and so um

2685
01:41:36,950 --> 01:41:35,360
if you go back to this picture and i

2686
01:41:39,189 --> 01:41:36,960
also have to be uh

2687
01:41:42,550 --> 01:41:39,199
mindful that what you measure in the

2688
01:41:45,030 --> 01:41:42,560

field is not co2 or bicarbonate what you

2689
01:41:47,350 --> 01:41:45,040
measure in the field is dic and so you

2690
01:41:50,629 --> 01:41:47,360
have to be to make sure that you

2691
01:41:52,550 --> 01:41:50,639
speciate the uh the

2692
01:41:55,830 --> 01:41:52,560
dic properly

2693
01:41:59,830 --> 01:41:55,840
because um as as you know the the

2694
01:42:02,629 --> 01:41:59,840
speciation of dic is ph dependent so

2695
01:42:04,149 --> 01:42:02,639
the ic will potentially go into co2

2696
01:42:06,709 --> 01:42:04,159
in acidic

2697
01:42:09,189 --> 01:42:06,719
environments potentially be in

2698
01:42:11,350 --> 01:42:09,199
h3o3 minus in

2699
01:42:12,629 --> 01:42:11,360
more in more neutral environments and

2700
01:42:15,270 --> 01:42:12,639
then at

2701
01:42:16,470 --> 01:42:15,280
alkaline in alkaline environments and

2702
01:42:18,229 --> 01:42:16,480
particularly in hyper-alkaline

2703
01:42:19,750 --> 01:42:18,239
environments they're essentially no co2

2704
01:42:21,270 --> 01:42:19,760
to speak of

2705
01:42:23,270 --> 01:42:21,280
so you kind of can already have an

2706
01:42:24,470 --> 01:42:23,280
intuition here that high alkaline

2707
01:42:27,109 --> 01:42:24,480
environments

2708
01:42:30,390 --> 01:42:27,119
the methanogenesis metabolisms that uses

2709
01:42:32,390 --> 01:42:30,400
co2 will not be uh will not be operating

2710
01:42:35,430 --> 01:42:32,400
very well

2711
01:42:38,149 --> 01:42:35,440
thank you yes i'm almost done

2712
01:42:39,270 --> 01:42:38,159
and so if you if you plot this so these

2713
01:42:40,950 --> 01:42:39,280

are kind of the results of this

2714
01:42:43,189 --> 01:42:40,960
numerical model here

2715
01:42:45,189 --> 01:42:43,199
i have the ph on the x-axis and the

2716
01:42:47,270 --> 01:42:45,199
hydrogen on the on the

2717
01:42:49,830 --> 01:42:47,280
y-axis and you can compute

2718
01:42:51,669 --> 01:42:49,840
the habitability index for these

2719
01:42:53,910 --> 01:42:51,679
different metabolisms so you can see

2720
01:42:56,070 --> 01:42:53,920
that on the figure on the left

2721
01:42:58,149 --> 01:42:56,080
you have essentially an environment that

2722
01:43:00,390 --> 01:42:58,159
has high ph is not habitable for the

2723
01:43:02,709 --> 01:43:00,400
metabolism that uses uh co2 because of

2724
01:43:05,109 --> 01:43:02,719
the speciation factor but if you're

2725
01:43:07,270 --> 01:43:05,119
quite using a bicarbonate then you you

2726
01:43:09,590 --> 01:43:07,280
should be fine so you can merge those

2727
01:43:12,070 --> 01:43:09,600
two together if you will in creating

2728
01:43:13,109 --> 01:43:12,080
kind of energy derived metabolic maps i

2729
01:43:14,629 --> 01:43:13,119
guess

2730
01:43:17,030 --> 01:43:14,639
where uh depending on what your

2731
01:43:20,310 --> 01:43:17,040
geochemistry is and if the the

2732
01:43:22,310 --> 01:43:20,320
biologists using 454 16s or other

2733
01:43:24,470 --> 01:43:22,320
combinations of letters and numbers to

2734
01:43:25,669 --> 01:43:24,480
identify what metallic what metabolisms

2735
01:43:28,550 --> 01:43:25,679
exist

2736
01:43:30,390 --> 01:43:28,560
then then you can plot there kind of

2737
01:43:31,830 --> 01:43:30,400
anticipates

2738
01:43:34,950 --> 01:43:31,840

what particular

2739
01:43:36,870 --> 01:43:34,960
metal metabolism the cell is using so

2740
01:43:39,109 --> 01:43:36,880
this is this kind of map is a cool way

2741
01:43:41,350 --> 01:43:39,119
to link the geochemistry and the

2742
01:43:44,070 --> 01:43:41,360
microbiology together

2743
01:43:45,590 --> 01:43:44,080
and so i have a few more minutes um

2744
01:43:47,430 --> 01:43:45,600
and so you can also play around with

2745
01:43:49,910 --> 01:43:47,440
temperature so what i'm doing is just

2746
01:43:51,750 --> 01:43:49,920
changing the right plot where i increase

2747
01:43:53,430 --> 01:43:51,760
the temperature from 20 to 50 degrees

2748
01:43:54,790 --> 01:43:53,440
this time it's the same metabolism and

2749
01:43:56,550 --> 01:43:54,800
of course the higher temperature your

2750
01:44:01,030 --> 01:43:56,560
maintenance energy goes up

2751
01:44:03,669 --> 01:44:01,040
your habitable space um goes down

2752
01:44:05,030 --> 01:44:03,679
so uh uh since everybody except frieder

2753
01:44:06,870 --> 01:44:05,040
included the gretchen's picture of

2754
01:44:08,870 --> 01:44:06,880
surprise night i thought i'd do it too

2755
01:44:10,709 --> 01:44:08,880
if you're interested in this

2756
01:44:12,870 --> 01:44:10,719
in methanogenesis in particular this is

2757
01:44:14,310 --> 01:44:12,880
the kind of the data i need

2758
01:44:16,229 --> 01:44:14,320
from you in the field if you're

2759
01:44:18,470 --> 01:44:16,239
interested in other metabolisms please

2760
01:44:22,229 --> 01:44:18,480
include me in your proposals

2761
01:44:24,790 --> 01:44:22,239
and to finish off then um

2762
01:44:27,189 --> 01:44:24,800
this this method of including power

2763
01:44:28,550 --> 01:44:27,199

provides a higher resolution assessment

2764
01:44:30,629 --> 01:44:28,560
habitability

2765
01:44:33,030 --> 01:44:30,639
compared to the delta g alone although

2766
01:44:35,430 --> 01:44:33,040
just calculating delta g is quick and

2767
01:44:37,910 --> 01:44:35,440
gives you a broad view of the landscape

2768
01:44:40,470 --> 01:44:37,920
and then you can target in a particular

2769
01:44:42,390 --> 01:44:40,480
area using this this method and finally

2770
01:44:44,149 --> 01:44:42,400
i think it's a cool way to put the

2771
01:44:46,070 --> 01:44:44,159
microbiology efforts

2772
01:44:48,950 --> 01:44:46,080
in within the geochemical context

2773
01:44:56,229 --> 01:44:48,960
through these energy derived microbial

2774
01:44:59,510 --> 01:44:58,149
thank you very much sanjoy i'm looking

2775
01:45:02,550 --> 01:44:59,520
forward to reading the paper when you

2776
01:45:03,510 --> 01:45:02,560
get this published so i can

2777
01:45:06,950 --> 01:45:03,520
yeah

2778
01:45:09,270 --> 01:45:06,960
i decided to get a dig in there

2779
01:45:11,990 --> 01:45:09,280
so we have one question here on the web

2780
01:45:14,950 --> 01:45:12,000
let's answer that question uh

2781
01:45:17,109 --> 01:45:14,960
uh so uh from frieder klein he uh he had

2782
01:45:20,629 --> 01:45:17,119
uh when you did the calculation for lost

2783
01:45:23,350 --> 01:45:20,639
city did you use the uh in situ ph to

2784
01:45:25,669 --> 01:45:23,360
compute the energy power landscape

2785
01:45:27,510 --> 01:45:25,679
uh he says the ones you measure are the

2786
01:45:33,430 --> 01:45:27,520
lister or the measured ones i think he

2787
01:45:36,550 --> 01:45:34,870
i don't remember where that value was

2788
01:45:38,870 --> 01:45:36,560

taken from i think it's just at the

2789
01:45:47,510 --> 01:45:38,880
vents

2790
01:45:51,990 --> 01:45:49,910
uh quickly then well uh there was one

2791
01:45:53,750 --> 01:45:52,000
other question uh

2792
01:45:58,229 --> 01:45:53,760
what about acetate fermentation to

2793
01:46:02,709 --> 01:46:00,390
co2 reduction

2794
01:46:06,310 --> 01:46:02,719
i haven't looked at acetate but i think

2795
01:46:07,830 --> 01:46:06,320
it's a logical next step to investigate

2796
01:46:09,830 --> 01:46:07,840
but how does okay um through the

2797
01:46:11,910 --> 01:46:09,840
membrane is

2798
01:46:14,310 --> 01:46:11,920
difficult so one of the the challenging

2799
01:46:16,149 --> 01:46:14,320
aspect of this of this type of approach

2800
01:46:17,189 --> 01:46:16,159
is you need to understand the biophysics

2801
01:46:19,350 --> 01:46:17,199
of how the

2802
01:46:20,790 --> 01:46:19,360
the uh substrate of interest goes

2803
01:46:23,109 --> 01:46:20,800
through the membrane

2804
01:46:27,030 --> 01:46:23,119
and so uh which is why it's not

2805
01:46:29,350 --> 01:46:27,040
trivial to to get these data so um

2806
01:46:31,109 --> 01:46:29,360
anybody who has some expertise in

2807
01:46:32,790 --> 01:46:31,119
the biophysics of membrane transport i'd

2808
01:46:36,149 --> 01:46:32,800
be very interested in

2809
01:46:40,149 --> 01:46:38,149
okay uh i think if there's any further

2810
01:46:43,109 --> 01:46:40,159
questions uh it's good to interact with

2811
01:46:44,790 --> 01:46:43,119
uh sanjoy on the web chat there

2812
01:46:47,990 --> 01:46:44,800
i think to keep things on we'll uh now

2813
01:46:51,189 --> 01:46:48,000

move to uh mike russell to the next

2814
01:46:53,030 --> 01:46:51,199
presenter from jpl

2815
01:46:55,270 --> 01:46:53,040
and uh

2816
01:46:57,669 --> 01:46:55,280
mike if you can

2817
01:46:58,950 --> 01:46:57,679
zone back in

2818
01:47:01,189 --> 01:46:58,960
yeah mike actually if you could start

2819
01:47:02,790 --> 01:47:01,199
with your webcam first um i'm going to

2820
01:47:03,910 --> 01:47:02,800
stop your screen share

2821
01:47:05,910 --> 01:47:03,920
um if you could actually start your

2822
01:47:07,189 --> 01:47:05,920
webcam first then we'll then we'll do

2823
01:47:10,790 --> 01:47:07,199
the screen share

2824
01:47:15,350 --> 01:47:12,870
there we go okay now we can hear you

2825
01:47:17,910 --> 01:47:15,360
fine uh yeah there you are

2826
01:47:19,350 --> 01:47:17,920
and uh right now i do this share my

2827
01:47:21,669 --> 01:47:19,360
screen

2828
01:47:23,510 --> 01:47:21,679
i'm just gonna ask uh

2829
01:47:25,590 --> 01:47:23,520
i know how passionate you get about

2830
01:47:27,830 --> 01:47:25,600
things when you start speaking but just

2831
01:47:30,470 --> 01:47:27,840
uh please try to keep things on on time

2832
01:47:35,510 --> 01:47:32,310
well i'm normally not too long anymore

2833
01:47:38,870 --> 01:47:35,520
anyway right can you see me can you see

2834
01:47:41,109 --> 01:47:38,880
yeah take it away please mike okay so

2835
01:47:42,390 --> 01:47:41,119
uh i used to think and i think a lot of

2836
01:47:44,149 --> 01:47:42,400
people thought that maybe

2837
01:47:47,189 --> 01:47:44,159
serpentinization might have been a kind

2838
01:47:49,030 --> 01:47:47,199

of pro so life and uh what i'm going to

2839
01:47:50,790 --> 01:47:49,040
try and talk about in this

2840
01:47:53,470 --> 01:47:50,800
short talk is that it's actually not

2841
01:47:55,189 --> 01:47:53,480
proto-life uh it's it's uh that

2842
01:47:56,709 --> 01:47:55,199
serpentinization i think that's the

2843
01:47:58,709 --> 01:47:56,719
mother of life but it's definitely not

2844
01:48:02,550 --> 01:47:58,719
its sister

2845
01:48:06,310 --> 01:48:04,229
how do i turn the next how do i get the

2846
01:48:08,709 --> 01:48:06,320
next one roughly

2847
01:48:11,430 --> 01:48:08,719
either click or use your keyboard okay i

2848
01:48:14,629 --> 01:48:11,440
got it uh okay so i think everybody's

2849
01:48:16,950 --> 01:48:14,639
seen a form of this this uh structure of

2850
01:48:18,550 --> 01:48:16,960
how plate tectonics or perhaps ocean

2851
01:48:20,390 --> 01:48:18,560
floor spreading or content or drift

2852
01:48:23,669 --> 01:48:20,400
might work but the point about it is

2853
01:48:25,109 --> 01:48:23,679
that it is an uh an engine whichever way

2854
01:48:27,430 --> 01:48:25,119
whatever you think was happening around

2855
01:48:29,750 --> 01:48:27,440
about 4.3 billion years ago it would

2856
01:48:31,270 --> 01:48:29,760
have been uh making new ocean floor of

2857
01:48:33,189 --> 01:48:31,280
some kind even if it was just with

2858
01:48:34,629 --> 01:48:33,199
plumes and that would be and we should

2859
01:48:36,310 --> 01:48:34,639
think of this as an engine so this is

2860
01:48:38,229 --> 01:48:36,320
one of the this is the primary engine

2861
01:48:39,990 --> 01:48:38,239
for us to worry about and of course the

2862
01:48:41,510 --> 01:48:40,000
engine is gives us positive feedback

2863
01:48:43,430 --> 01:48:41,520

because of the high density of lack of

2864
01:48:44,550 --> 01:48:43,440
diet which is gives you the positive

2865
01:48:46,550 --> 01:48:44,560
feedback of

2866
01:48:47,510 --> 01:48:46,560
giving you the body force that brings

2867
01:48:53,030 --> 01:48:47,520
the

2868
01:48:55,189 --> 01:48:53,040
whatever magmar it is rises because of

2869
01:48:57,510 --> 01:48:55,199
its relative buoyancy but you need both

2870
01:48:59,830 --> 01:48:57,520
for the continuation so if we have that

2871
01:49:00,950 --> 01:48:59,840
sense then of course we can now switch

2872
01:49:03,510 --> 01:49:00,960
to saying right what's the

2873
01:49:05,750 --> 01:49:03,520
sepentimization engine like that and the

2874
01:49:07,189 --> 01:49:05,760
sependenization engine is basically and

2875
01:49:10,310 --> 01:49:07,199
i'm sure this much of this has been

2876
01:49:12,709 --> 01:49:10,320
covered is it's it's uh suffering it's

2877
01:49:15,030 --> 01:49:12,719
it's partly due to the convective stress

2878
01:49:17,990 --> 01:49:15,040
uh that it's suffering due to the uh

2879
01:49:21,030 --> 01:49:18,000
plate tectonics or whatever or plume

2880
01:49:23,109 --> 01:49:21,040
tectonics uh and so that cracks the rock

2881
01:49:24,149 --> 01:49:23,119
the rock cracks the water comes down it

2882
01:49:25,270 --> 01:49:24,159
increases

2883
01:49:28,070 --> 01:49:25,280
the uh

2884
01:49:30,550 --> 01:49:28,080
permeability it increases the

2885
01:49:32,070 --> 01:49:30,560
poor pressure so you've got a positive

2886
01:49:33,430 --> 01:49:32,080
feedback almost immediately and of

2887
01:49:37,669 --> 01:49:33,440
course as we know it's uh it's

2888
01:49:40,310 --> 01:49:37,679

exothermic uh it reduces calm it reduces

2889
01:49:44,709 --> 01:49:40,320
uh water to hydrogen as we've heard and

2890
01:49:47,510 --> 01:49:44,719
maybe slowly reduces uh co2 or carb

2891
01:49:49,189 --> 01:49:47,520
bicarbonate to uh methane perhaps that's

2892
01:49:51,830 --> 01:49:49,199
slow but eventually but anyway the

2893
01:49:55,030 --> 01:49:51,840
sebentonization engine gives us hydrogen

2894
01:49:59,669 --> 01:49:55,040
some methane and some formate so that's

2895
01:50:03,830 --> 01:50:01,589
so we thought we'd have a look at this

2896
01:50:06,629 --> 01:50:03,840
kind of serpentinization reaction but

2897
01:50:09,350 --> 01:50:06,639
within uh this equilibrium experiment

2898
01:50:10,629 --> 01:50:09,360
that is that we're looking at uh

2899
01:50:12,310 --> 01:50:10,639
not only

2900
01:50:13,990 --> 01:50:12,320
so we're not doing a single part

2901
01:50:15,510 --> 01:50:14,000
experiment it's a two-part experiment if

2902
01:50:18,070 --> 01:50:15,520
we switch every four hours we have it

2903
01:50:20,310 --> 01:50:18,080
about 120 degrees centigrade and the one

2904
01:50:21,830 --> 01:50:20,320
extraordinary thing to us anyway to my

2905
01:50:26,709 --> 01:50:21,840
disappointment initially was that we'd

2906
01:50:28,310 --> 01:50:26,719
made no methane using uh co213 so

2907
01:50:30,550 --> 01:50:28,320
carbon-13

2908
01:50:32,229 --> 01:50:30,560
and of course at the same time or sorry

2909
01:50:33,830 --> 01:50:32,239
pre-publishing us is mccollum and

2910
01:50:35,430 --> 01:50:33,840
donaldson's paper which comes to the

2911
01:50:37,270 --> 01:50:35,440
same conclusion that we don't make

2912
01:50:39,910 --> 01:50:37,280
methane at least quickly in

2913
01:50:42,470 --> 01:50:39,920

sepentineization reckon

2914
01:50:44,229 --> 01:50:42,480
reactions what we do make is formate so

2915
01:50:46,629 --> 01:50:44,239
you could say that the formate reaction

2916
01:50:49,910 --> 01:50:46,639
tells us something about co2 reduction

2917
01:50:53,189 --> 01:50:49,920
to formate or co and that could be

2918
01:50:57,109 --> 01:50:53,199
perhaps segued into one part of the

2919
01:50:59,510 --> 01:50:57,119
acetyl-coenzyme synthase pathway

2920
01:51:01,350 --> 01:50:59,520
uh so here's here's uh the fact of this

2921
01:51:03,589 --> 01:51:01,360
and that is that we've got and we think

2922
01:51:05,510 --> 01:51:03,599
this is fair enough we've got hydrogen

2923
01:51:07,189 --> 01:51:05,520
the hydrothermal solution interacting

2924
01:51:09,030 --> 01:51:07,199
with the ocean solution every four hours

2925
01:51:11,830 --> 01:51:09,040
switching and you can see every time the

2926
01:51:14,070 --> 01:51:11,840
hydrothermal solution comes in we drop

2927
01:51:16,790 --> 01:51:14,080
uh methane but every time the ocean

2928
01:51:19,430 --> 01:51:16,800
comes up uh the ocean solution is put

2929
01:51:21,430 --> 01:51:19,440
into the uh sebentonization reaction

2930
01:51:23,189 --> 01:51:21,440
then we get not only the magnesium

2931
01:51:24,790 --> 01:51:23,199
coming through but also the format so it

2932
01:51:26,870 --> 01:51:24,800
looks as though that's a very rapid i

2933
01:51:28,470 --> 01:51:26,880
won't say instantaneous but extremely

2934
01:51:29,910 --> 01:51:28,480
rapid reaction

2935
01:51:32,070 --> 01:51:29,920
so i don't want to go through this

2936
01:51:34,070 --> 01:51:32,080
particularly but just to remind us that

2937
01:51:35,910 --> 01:51:34,080
we should think about the pentamizations

2938
01:51:38,709 --> 01:51:35,920

the pentanization as an engine it's an

2939
01:51:39,990 --> 01:51:38,719
auto catalytic collective uh and i'll

2940
01:51:42,629 --> 01:51:40,000
just give you a few of these which

2941
01:51:44,870 --> 01:51:42,639
you've probably had uh the matrix cross

2942
01:51:49,030 --> 01:51:44,880
becomes unstable because it's

2943
01:51:51,430 --> 01:51:49,040
its resistance tectonic stress uh crack

2944
01:51:54,310 --> 01:51:51,440
because it's it fails and becomes

2945
01:51:55,910 --> 01:51:54,320
unstable uh to due to the tectonic

2946
01:51:58,310 --> 01:51:55,920
stress and the cracks form and compete

2947
01:52:00,550 --> 01:51:58,320
and multiply and so forth and uh one of

2948
01:52:01,350 --> 01:52:00,560
the things that i think is open to

2949
01:52:02,629 --> 01:52:01,360
uh

2950
01:52:04,629 --> 01:52:02,639
and we i think we've done the rest but

2951
01:52:06,070 --> 01:52:04,639
negative feedback significant what we

2952
01:52:07,830 --> 01:52:06,080
would like to call the governor or our

2953
01:52:09,350 --> 01:52:07,840
thermostatic and i think there's some

2954
01:52:11,510 --> 01:52:09,360
disagreement about that and i've heard

2955
01:52:14,550 --> 01:52:11,520
some of the disagreements so far but i

2956
01:52:16,070 --> 01:52:14,560
saw the prosperous paper suggesting 140

2957
01:52:18,310 --> 01:52:16,080
degree centigrade maximum of the

2958
01:52:20,149 --> 01:52:18,320
hydrogen isotopes makes a lot of sense

2959
01:52:22,149 --> 01:52:20,159
to me and the carbon the carbon and the

2960
01:52:24,149 --> 01:52:22,159
carbonate perhaps makes less than so we

2961
01:52:25,510 --> 01:52:24,159
would think that that's due to softening

2962
01:52:27,350 --> 01:52:25,520
of the crust and that's why we get a

2963
01:52:29,430 --> 01:52:27,360

thermostatic system for these lower

2964
01:52:31,510 --> 01:52:29,440
temperature alkaline non-magmatic

2965
01:52:33,589 --> 01:52:31,520
systems of around about 100 degrees

2966
01:52:35,430 --> 01:52:33,599
centigrade once they come towards the

2967
01:52:37,669 --> 01:52:35,440
surface and i've just emphasized that

2968
01:52:40,149 --> 01:52:37,679
they last these systems last for about a

2969
01:52:42,310 --> 01:52:40,159
hundred thousand years and uh and they

2970
01:52:44,229 --> 01:52:42,320
last i prefer to call it 10 to the 21

2971
01:52:45,910 --> 01:52:44,239
nanoseconds we have to think on the pico

2972
01:52:48,310 --> 01:52:45,920
and nanoscale if we're thinking about

2973
01:52:50,310 --> 01:52:48,320
the emergence of systems such as life

2974
01:52:53,270 --> 01:52:50,320
this is i would partly deal with this in

2975
01:52:55,350 --> 01:52:53,280
a paper just coming almost out

2976
01:52:57,189 --> 01:52:55,360
should be out next week branska metal

2977
01:52:59,510 --> 01:52:57,199
escapement mechanisms and the conversion

2978
01:53:01,189 --> 01:52:59,520
of disequilibrium so our story is all

2979
01:53:02,950 --> 01:53:01,199
about this equilibrium and the engines

2980
01:53:04,470 --> 01:53:02,960
of creation

2981
01:53:06,390 --> 01:53:04,480
so this is what we used to say and i

2982
01:53:08,950 --> 01:53:06,400
wasn't i feel embarrassed about it but

2983
01:53:10,790 --> 01:53:08,960
we suggested that perhaps methanogenesis

2984
01:53:12,189 --> 01:53:10,800
was uh

2985
01:53:14,550 --> 01:53:12,199
the beginning of life and therefore

2986
01:53:16,070 --> 01:53:14,560
sependenization was significant to that

2987
01:53:20,149 --> 01:53:16,080
effect so here we have it on the right

2988
01:53:21,830 --> 01:53:20,159

hand side perhaps ch4 was the first uh

2989
01:53:23,030 --> 01:53:21,840
formation of

2990
01:53:26,149 --> 01:53:23,040
the first

2991
01:53:27,910 --> 01:53:26,159
auto catalytic metabolism system but we

2992
01:53:29,669 --> 01:53:27,920
no longer think that's the case partly

2993
01:53:32,470 --> 01:53:29,679
because we can't make it very quickly

2994
01:53:34,550 --> 01:53:32,480
and anything that is chemical uh that

2995
01:53:36,709 --> 01:53:34,560
we're going to try to bring in to use

2996
01:53:37,669 --> 01:53:36,719
for the emergence of life must be fast

2997
01:53:39,350 --> 01:53:37,679
almost

2998
01:53:41,830 --> 01:53:39,360
instantaneous but this is not true of

2999
01:53:44,390 --> 01:53:41,840
methane so we've kind of given that out

3000
01:53:46,390 --> 01:53:44,400
and now suggest that uh

3001
01:53:48,629 --> 01:53:46,400
we go back to looking at the early earth

3002
01:53:50,950 --> 01:53:48,639
this is not a very good diagram but what

3003
01:53:53,270 --> 01:53:50,960
it shows is the hydrogen methane and

3004
01:53:56,070 --> 01:53:53,280
hydroxyls of an alkaline solution are

3005
01:53:58,790 --> 01:53:56,080
well out of equilibrium with uh the

3006
01:54:01,109 --> 01:53:58,800
acidulous ocean but also with uh nitric

3007
01:54:03,669 --> 01:54:01,119
oxide which we would say is uh

3008
01:54:05,669 --> 01:54:03,679
sufficient to produce nitric

3009
01:54:07,750 --> 01:54:05,679
nitrate in the ocean something to about

3010
01:54:10,790 --> 01:54:07,760
10 millimeter 10 micromoles which is

3011
01:54:13,030 --> 01:54:10,800
enough to uh we would say use up

3012
01:54:14,790 --> 01:54:13,040
actually uh burn if you like the methane

3013
01:54:16,709 --> 01:54:14,800

and the hydrogen and so in other words

3014
01:54:19,589 --> 01:54:16,719
we are going to suggest

3015
01:54:21,830 --> 01:54:19,599
thanotrophy first not methanogenesis

3016
01:54:24,310 --> 01:54:21,840
unfortunately methanogenesis

3017
01:54:25,910 --> 01:54:24,320
has given because it had prime of place

3018
01:54:27,910 --> 01:54:25,920
uh we think of metastatic trophies

3019
01:54:30,310 --> 01:54:27,920
reverse methanogenesis but i would ask

3020
01:54:32,109 --> 01:54:30,320
you to rethink that and say well could

3021
01:54:34,390 --> 01:54:32,119
it be that actually

3022
01:54:36,629 --> 01:54:34,400
methanogenesis is referred to reverse

3023
01:54:39,189 --> 01:54:36,639
methanotrophy just a thought but one to

3024
01:54:42,229 --> 01:54:39,199
bear in mind i think so if we move on to

3025
01:54:44,149 --> 01:54:42,239
what we look at in the actual membranes

3026
01:54:46,790 --> 01:54:44,159
that are produced now as you know much

3027
01:54:48,709 --> 01:54:46,800
of the precipitates at lost city are

3028
01:54:50,709 --> 01:54:48,719
basically uh

3029
01:54:52,870 --> 01:54:50,719
well the first precipitation is bruce

3030
01:54:54,149 --> 01:54:52,880
site and some carbonate

3031
01:54:55,750 --> 01:54:54,159
and but this would not have been the

3032
01:54:57,350 --> 01:54:55,760
same in the early ocean where of course

3033
01:54:59,990 --> 01:54:57,360
there's enough iron in the early ocean

3034
01:55:02,149 --> 01:55:00,000
to make a brewsty-type mineral but in

3035
01:55:04,149 --> 01:55:02,159
this case it would be a green rust and

3036
01:55:08,310 --> 01:55:04,159
the the difference between that is it's

3037
01:55:10,550 --> 01:55:08,320
a double layer hydroxide which uses uh

3038
01:55:13,830 --> 01:55:10,560

the anions uh to

3039
01:55:17,189 --> 01:55:13,840
get charge uh equivalents so

3040
01:55:18,790 --> 01:55:17,199
if we just take one known example of uh

3041
01:55:21,030 --> 01:55:18,800
using this kind of bruce light type

3042
01:55:23,030 --> 01:55:21,040
mineral green rust and we suggest that

3043
01:55:25,350 --> 01:55:23,040
we put it as part of the membrane then

3044
01:55:27,270 --> 01:55:25,360
on the outside we've got nitrate carbon

3045
01:55:29,430 --> 01:55:27,280
dioxide uh

3046
01:55:30,629 --> 01:55:29,440
low ph on the other side we've got high

3047
01:55:33,589 --> 01:55:30,639
ph

3048
01:55:34,550 --> 01:55:33,599
and we've got uh hydrogen and uh

3049
01:55:39,669 --> 01:55:34,560
and

3050
01:55:41,510 --> 01:55:39,679
that right now but these the two are

3051
01:55:43,189 --> 01:55:41,520
obviously very far from equilibrium and

3052
01:55:45,510 --> 01:55:43,199
we would suggest that the nitrate what

3053
01:55:47,990 --> 01:55:45,520
the nitrate does is it oxidizes the

3054
01:55:51,189 --> 01:55:48,000
green rust uh and of course as soon as

3055
01:55:53,990 --> 01:55:51,199
it does that it opens up a kind of crawl

3056
01:55:56,629 --> 01:55:54,000
for the nitrate to get in to uh to

3057
01:55:58,310 --> 01:55:56,639
balance charge and uh if there's more

3058
01:56:00,390 --> 01:55:58,320
nitrate on the outside then of course

3059
01:56:03,430 --> 01:56:00,400
it'll be forced in and be reduced to

3060
01:56:05,270 --> 01:56:03,440
nitrite as the uh bruce light gets

3061
01:56:07,510 --> 01:56:05,280
oxidized and eventually it'll go down to

3062
01:56:09,189 --> 01:56:07,520
hno which is uncharged therefore you can

3063
01:56:11,189 --> 01:56:09,199

kind of push it through because it's

3064
01:56:13,270 --> 01:56:11,199
loose it'll be loose within that

3065
01:56:15,669 --> 01:56:13,280
interlayer and the protons will help to

3066
01:56:17,830 --> 01:56:15,679
drive it through and help to reduce uh

3067
01:56:19,910 --> 01:56:17,840
nitrate to ammonia and that can be done

3068
01:56:23,109 --> 01:56:19,920
in three hours uh

3069
01:56:26,470 --> 01:56:23,119
just by bucket chemistry and nitrite can

3070
01:56:27,910 --> 01:56:26,480
be can be reduced to ammonium in in one

3071
01:56:29,270 --> 01:56:27,920
hour and i think that that's hugely

3072
01:56:31,669 --> 01:56:29,280
significant because we always think it's

3073
01:56:34,629 --> 01:56:31,679
just co2 and of course i do like to say

3074
01:56:36,790 --> 01:56:34,639
that uh life hydrogenates carbon dioxide

3075
01:56:39,270 --> 01:56:36,800
but it also makes them

3076
01:56:41,350 --> 01:56:39,280
makes an aminating compound as well from

3077
01:56:43,750 --> 01:56:41,360
nitrate we would say and that's a very

3078
01:56:45,430 --> 01:56:43,760
good source of nitrogen for amino acids

3079
01:56:47,750 --> 01:56:45,440
and nucleic acids which is otherwise

3080
01:56:49,350 --> 01:56:47,760
missing by the way for most hypotheses

3081
01:56:51,750 --> 01:56:49,360
so we think of that as a ramjet i won't

3082
01:56:53,189 --> 01:56:51,760
go into that uh but so the real problem

3083
01:56:56,310 --> 01:56:53,199
facing us is how do we get from a

3084
01:56:58,550 --> 01:56:56,320
hydrothermal mound to the the last

3085
01:57:00,310 --> 01:56:58,560
universal common ancestor and then

3086
01:57:02,229 --> 01:57:00,320
eventually the of course the

3087
01:57:04,550 --> 01:57:02,239
evolutionary tree how can we and i've

3088
01:57:07,589 --> 01:57:04,560

kind of made a secretive kind of

3089
01:57:08,310 --> 01:57:07,599
cava a canyon here to try and cross how

3090
01:57:12,229 --> 01:57:08,320
can

3091
01:57:13,910 --> 01:57:12,239
to the right hand of this diagram

3092
01:57:16,550 --> 01:57:13,920
there's lots of things going for it in

3093
01:57:18,470 --> 01:57:16,560
terms of uh ph gradients and so forth

3094
01:57:20,709 --> 01:57:18,480
and of course uh the greg eye being

3095
01:57:22,709 --> 01:57:20,719
formed very similar to acetone

3096
01:57:25,270 --> 01:57:22,719
coenzyme synthase and carbon monoxide

3097
01:57:27,109 --> 01:57:25,280
dehydrogenase but really we should i

3098
01:57:28,709 --> 01:57:27,119
think we've been missing the point we've

3099
01:57:30,149 --> 01:57:28,719
really it's going to be hard to get

3100
01:57:31,350 --> 01:57:30,159
right across and i think we need a

3101
01:57:32,629 --> 01:57:31,360
vehicle

3102
01:57:34,790 --> 01:57:32,639
uh so

3103
01:57:37,109 --> 01:57:34,800
and what do we actually need to get to

3104
01:57:38,629 --> 01:57:37,119
our a must be the ribosome we've

3105
01:57:39,830 --> 01:57:38,639
actually got to get a ribosome we can't

3106
01:57:42,229 --> 01:57:39,840
mess around with a little bit of

3107
01:57:44,629 --> 01:57:42,239
metabolism and then try and look for uh

3108
01:57:46,629 --> 01:57:44,639
information system and and so forth

3109
01:57:48,310 --> 01:57:46,639
we've got to have everything together i

3110
01:57:50,870 --> 01:57:48,320
would say and therefore we're aiming for

3111
01:57:53,830 --> 01:57:50,880
a ribosome now that's a big aim so let's

3112
01:57:56,709 --> 01:57:53,840
see what possibility we have here and

3113
01:57:58,870 --> 01:57:56,719

what we'd say was the first ribosome uh

3114
01:58:00,870 --> 01:57:58,880
according to bernhard and plate was

3115
01:58:02,470 --> 01:58:00,880
could think of entirely in terms of

3116
01:58:04,550 --> 01:58:02,480
peptides

3117
01:58:06,550 --> 01:58:04,560
and in fact the ribosome has an

3118
01:58:08,550 --> 01:58:06,560
ancestral ribosome or peptide anyway

3119
01:58:10,870 --> 01:58:08,560
there's plenty of glycine in and and

3120
01:58:14,070 --> 01:58:10,880
that's the linear peptide and it looks

3121
01:58:16,470 --> 01:58:14,080
as though according to should we say

3122
01:58:18,709 --> 01:58:16,480
williams at our lorem williams that

3123
01:58:21,030 --> 01:58:18,719
probably it could be that the peptide

3124
01:58:22,470 --> 01:58:21,040
was first and that the rna and dna came

3125
01:58:23,990 --> 01:58:22,480
later and i would certainly agree with

3126
01:58:25,270 --> 01:58:24,000
that in fact i don't think rna was

3127
01:58:28,229 --> 01:58:25,280
significant at all i think it went

3128
01:58:29,990 --> 01:58:28,239
probably escape to the nucleic acids

3129
01:58:31,510 --> 01:58:30,000
anyway so what can we do here well we've

3130
01:58:32,790 --> 01:58:31,520
got hanging in the

3131
01:58:34,790 --> 01:58:32,800
uh

3132
01:58:36,870 --> 01:58:34,800
on the curtain so to speak is green rust

3133
01:58:39,589 --> 01:58:36,880
so can we and green rust is that double

3134
01:58:42,310 --> 01:58:39,599
layered hydroxide uh which can take in

3135
01:58:45,189 --> 01:58:42,320
the anions as i said now can we get

3136
01:58:46,870 --> 01:58:45,199
across this canyon using green rust well

3137
01:58:49,589 --> 01:58:46,880
let's have a look at something that was

3138
01:58:53,669 --> 01:58:49,599

suggested by the way in

3139
01:58:55,990 --> 01:58:53,679
1903 that in fact darwin's uh

3140
01:58:57,189 --> 01:58:56,000
system darwin's evolution actually had

3141
01:59:00,070 --> 01:58:57,199
to have a governor had to have a

3142
01:59:03,669 --> 01:59:00,080
guidance system and uh and this uh

3143
01:59:06,149 --> 01:59:03,679
barclay in 1903 suggested he was just a

3144
01:59:07,750 --> 01:59:06,159
layered in scotland in some uh

3145
01:59:09,830 --> 01:59:07,760
estate in in

3146
01:59:11,669 --> 01:59:09,840
east uh northern scotland uh and he

3147
01:59:14,709 --> 01:59:11,679
suggested well how about comparing to a

3148
01:59:17,030 --> 01:59:14,719
yacht guard loom uh and that was uh

3149
01:59:19,669 --> 01:59:17,040
invented in 1801 and and of course

3150
01:59:22,629 --> 01:59:19,679
that's what inspired uh babbage and uh

3151
01:59:24,790 --> 01:59:22,639
ada lovelace to go for that digital idea

3152
01:59:26,390 --> 01:59:24,800
of the difference engine but actually

3153
01:59:29,350 --> 01:59:26,400
that's that was 40 years later but the

3154
01:59:32,149 --> 01:59:29,360
jackard loom is not dissimilar as

3155
01:59:34,070 --> 01:59:32,159
actually drexler pointed out some time

3156
01:59:36,229 --> 01:59:34,080
ago that the track

3157
01:59:38,310 --> 01:59:36,239
because of the what it does is it

3158
01:59:41,589 --> 01:59:38,320
automatically makes material the output

3159
01:59:42,709 --> 01:59:41,599
is material by by this automatic uh

3160
01:59:44,709 --> 01:59:42,719
machine

3161
01:59:46,870 --> 01:59:44,719
and it's extremely well i shouldn't say

3162
01:59:48,550 --> 01:59:46,880
extremely but it's comparable to the

3163
01:59:50,550 --> 01:59:48,560

ribosome and how the ribosome works so

3164
01:59:53,510 --> 01:59:50,560
on the right hand side you've got those

3165
01:59:56,550 --> 01:59:53,520
uh digital system going through and it

3166
01:59:59,510 --> 01:59:56,560
generates uh the output is protein newly

3167
02:00:02,070 --> 01:59:59,520
born protein or peptide anyway and on

3168
02:00:04,709 --> 02:00:02,080
this on the other side there is the uh

3169
02:00:09,669 --> 02:00:07,270
so uh if we then look at green rust and

3170
02:00:11,030 --> 02:00:09,679
we look at uh jeanine and ruby and other

3171
02:00:12,629 --> 02:00:11,040
people's work

3172
02:00:15,350 --> 02:00:12,639
you'll see that actually it's

3173
02:00:18,390 --> 02:00:15,360
extraordinary complicated system uh

3174
02:00:20,550 --> 02:00:18,400
which can vary uh so what we would say

3175
02:00:23,510 --> 02:00:20,560
is that that steric ion could be thought

3176
02:00:25,189 --> 02:00:23,520
of as the as the ones and the ferrous

3177
02:00:27,270 --> 02:00:25,199
ion could be thought of the zero so

3178
02:00:29,750 --> 02:00:27,280
you've got a zero one system in green

3179
02:00:32,310 --> 02:00:29,760
rushes it oxidizes and reduces now of

3180
02:00:34,709 --> 02:00:32,320
course it's a dynamic system uh and it's

3181
02:00:35,910 --> 02:00:34,719
an oscillating system as well so it

3182
02:00:40,790 --> 02:00:35,920
would start

3183
02:00:42,390 --> 02:00:40,800
going to start just by additions

3184
02:00:44,390 --> 02:00:42,400
but i think that that probably is a good

3185
02:00:46,470 --> 02:00:44,400
thing rather than the bad thing

3186
02:00:49,669 --> 02:00:46,480
so here's another example of one of the

3187
02:00:51,589 --> 02:00:49,679
readouts from you get from uh

3188
02:00:52,830 --> 02:00:51,599

from green rust and there's a comparison

3189
02:00:55,910 --> 02:00:52,840
with the

3190
02:00:58,229 --> 02:00:55,920
uh the jacquard loom uh

3191
02:00:59,270 --> 02:00:58,239
inputs uh the dot basically that alteram

3192
02:01:01,350 --> 02:00:59,280
ones

3193
02:01:03,589 --> 02:01:01,360
and so we then

3194
02:01:06,070 --> 02:01:03,599
appeal to green wool and covenant a

3195
02:01:08,390 --> 02:01:06,080
lovely paper in 2006 in the origin of

3196
02:01:10,550 --> 02:01:08,400
life where they show that in fact you

3197
02:01:13,109 --> 02:01:10,560
could use green rust as an information

3198
02:01:14,790 --> 02:01:13,119
and storage and transfer system uh and

3199
02:01:18,229 --> 02:01:14,800
if we put that across the membrane there

3200
02:01:21,350 --> 02:01:18,239
we've got uh this kind of system which

3201
02:01:23,910 --> 02:01:21,360
could give you a storage and information

3202
02:01:25,350 --> 02:01:23,920
they of course employ dna and rna and we

3203
02:01:27,990 --> 02:01:25,360
would suggest that that wouldn't be the

3204
02:01:31,510 --> 02:01:28,000
case we would suggest that this would uh

3205
02:01:34,310 --> 02:01:31,520
actually control through diffusion and

3206
02:01:36,229 --> 02:01:34,320
so forth and reaction rates it would

3207
02:01:37,990 --> 02:01:36,239
control the generation of particular

3208
02:01:40,149 --> 02:01:38,000
organic molecules and those that are the

3209
02:01:42,229 --> 02:01:40,159
most successful and interact are the

3210
02:01:44,229 --> 02:01:42,239
ones that will continue and those that

3211
02:01:48,550 --> 02:01:44,239
don't interact are just pushed to the

3212
02:01:51,030 --> 02:01:48,560
side perhaps as amyloidal peptide

3213
02:01:54,070 --> 02:01:51,040

so here's a system in a little more

3214
02:01:56,390 --> 02:01:54,080
complex way uh so the nitrate goes in on

3215
02:01:59,270 --> 02:01:56,400
the left from the ocean it's reduced by

3216
02:02:01,030 --> 02:01:59,280
the protons and the electrons from uh

3217
02:02:02,629 --> 02:02:01,040
from the uh

3218
02:02:05,109 --> 02:02:02,639
alkaline hydrothermal system through

3219
02:02:07,189 --> 02:02:05,119
this can semi-conducting mineral green

3220
02:02:10,629 --> 02:02:07,199
rust and you can see you can get down to

3221
02:02:12,709 --> 02:02:10,639
ammonium the ammonium then can get to uh

3222
02:02:14,390 --> 02:02:12,719
react uh with

3223
02:02:15,589 --> 02:02:14,400
uh the

3224
02:02:17,030 --> 02:02:15,599
uh

3225
02:02:20,070 --> 02:02:17,040
i haven't quite got this here so i've

3226
02:02:20,950 --> 02:02:20,080
got the reaction we get em sorry we get

3227
02:02:21,910 --> 02:02:20,960
uh

3228
02:02:36,790 --> 02:02:21,920
the

3229
02:02:38,629 --> 02:02:36,800
same system

3230
02:02:39,350 --> 02:02:38,639
so here it is in in

3231
02:02:42,229 --> 02:02:39,360
its

3232
02:02:44,629 --> 02:02:42,239
relative entirety nitrate to ammonium on

3233
02:02:47,109 --> 02:02:44,639
the top through the top layer

3234
02:02:49,750 --> 02:02:47,119
and then the next layer is the the

3235
02:02:52,790 --> 02:02:49,760
nitric oxide halfway along that top

3236
02:02:55,189 --> 02:02:52,800
layer is used to oxidize the methane

3237
02:02:58,149 --> 02:02:55,199
to uh in a very complex way that

3238
02:03:01,589 --> 02:02:58,159

actually employs electron bifurcation to

3239
02:03:03,510 --> 02:03:01,599
give you the the the

3240
02:03:05,990 --> 02:03:03,520
methyl group and the

3241
02:03:07,510 --> 02:03:06,000
uh aminogen and the immunogen can react

3242
02:03:09,270 --> 02:03:07,520
with the uh

3243
02:03:12,149 --> 02:03:09,280
something like pyruvate for example

3244
02:03:15,270 --> 02:03:12,159
george cody's given us pyruvate uh and

3245
02:03:16,790 --> 02:03:15,280
uh lori barge has used pyruvate in her

3246
02:03:18,870 --> 02:03:16,800
reactions to show that you can actually

3247
02:03:20,790 --> 02:03:18,880
make alanine almost immediately make

3248
02:03:23,350 --> 02:03:20,800
polyalamine uh

3249
02:03:25,910 --> 02:03:23,360
if you would use a carbonate uh and so

3250
02:03:28,229 --> 02:03:25,920
you you start you've got a very short

3251
02:03:30,390 --> 02:03:28,239
peptide something like five four or five

3252
02:03:32,870 --> 02:03:30,400
or six mer peptide which is enough to do

3253
02:03:35,589 --> 02:03:32,880
an awful lot of uh sequestration of

3254
02:03:38,229 --> 02:03:35,599
phosphates and uh sulfites and so forth

3255
02:03:40,629 --> 02:03:38,239
and even enough to make a kind of

3256
02:03:42,470 --> 02:03:40,639
membrane around the outside now this is

3257
02:03:44,790 --> 02:03:42,480
current but just to give you where we're

3258
02:03:46,629 --> 02:03:44,800
going with this is to suggest that

3259
02:03:49,270 --> 02:03:46,639
actually we've got a sepentinization

3260
02:03:51,830 --> 02:03:49,280
engine that spawns life's engine and

3261
02:03:53,910 --> 02:03:51,840
that's ventinization gives us hydro uh

3262
02:03:57,030 --> 02:03:53,920
hydrogen crustal leachate gives us the

3263
02:03:59,830 --> 02:03:57,040

methane the two together

3264
02:04:01,990 --> 02:03:59,840
into reacting with nitrate through uh

3265
02:04:05,109 --> 02:04:02,000
proton motive force and by electron

3266
02:04:06,550 --> 02:04:05,119
bifurcation gives us carbon monoxide on

3267
02:04:09,189 --> 02:04:06,560
the one side of methyl group on the

3268
02:04:12,310 --> 02:04:09,199
other and you get to the target molecule

3269
02:04:14,149 --> 02:04:12,320
for for example the uh the krebs cycle

3270
02:04:16,149 --> 02:04:14,159
the the reverse krebs cycle the

3271
02:04:18,229 --> 02:04:16,159
incomplete reverse krebs cycle gives you

3272
02:04:19,990 --> 02:04:18,239
the acetone group and i we would say

3273
02:04:21,990 --> 02:04:20,000
that's once you've got there you're off

3274
02:04:23,510 --> 02:04:22,000
so we would say maybe that's the way to

3275
02:04:25,510 --> 02:04:23,520
do it that we actually try and do it in

3276
02:04:27,750 --> 02:04:25,520
a wanner we don't kind of go through

3277
02:04:29,750 --> 02:04:27,760
using little vesicles or anything like

3278
02:04:32,950 --> 02:04:29,760
that we actually say those

3279
02:04:35,350 --> 02:04:32,960
membrane minerals with their uh gated

3280
02:04:37,669 --> 02:04:35,360
mechanisms actually do the real job of

3281
02:04:39,589 --> 02:04:37,679
the cell and so we would take the

3282
02:04:42,310 --> 02:04:39,599
extreme view that if you want to look

3283
02:04:43,990 --> 02:04:42,320
for the original cell it wasn't unlike a

3284
02:04:46,470 --> 02:04:44,000
green rust which were all about the same

3285
02:04:47,910 --> 02:04:46,480
size by the way uh you know

3286
02:04:50,830 --> 02:04:47,920
depending on the interactions but

3287
02:04:53,750 --> 02:04:50,840
generally at the micron or submicron

3288
02:04:56,229 --> 02:04:53,760

level and uh

3289
02:04:58,069 --> 02:04:56,239
these are people that helped me a lot

3290
02:05:00,069 --> 02:04:58,079
with all this and patrick beckett at the

3291
02:05:02,069 --> 02:05:00,079
top wolfgang nichka and albert

3292
02:05:03,830 --> 02:05:02,079
branscomber who i believe or hope is

3293
02:05:05,350 --> 02:05:03,840
online and will be emailing me

3294
02:05:07,669 --> 02:05:05,360
thereafter

3295
02:05:10,709 --> 02:05:07,679
please open okay that's it

3296
02:05:12,470 --> 02:05:10,719
thank you wow thank you very much uh

3297
02:05:16,310 --> 02:05:12,480
mike i think i see everybody's hair

3298
02:05:19,270 --> 02:05:16,320
appropriately swept back after that

3299
02:05:21,750 --> 02:05:19,280
a tour de force presentation and

3300
02:05:23,350 --> 02:05:21,760
uh we did have a couple of questions

3301
02:05:25,589 --> 02:05:23,360
that came up during the talk maybe we

3302
02:05:27,990 --> 02:05:25,599
can uh address those uh

3303
02:05:31,270 --> 02:05:28,000
uh frieder klein uh asked some questions

3304
02:05:33,350 --> 02:05:31,280
about the green russ uh he asked would

3305
02:05:35,270 --> 02:05:33,360
you mind explaining which reactions led

3306
02:05:36,629 --> 02:05:35,280
to the formation of green rocks in the

3307
02:05:38,629 --> 02:05:36,639
hayden ocean

3308
02:05:41,270 --> 02:05:38,639
and what kinds of green rust would you

3309
02:05:43,750 --> 02:05:41,280
expect to form

3310
02:05:45,189 --> 02:05:43,760
uh well of course that depends on what

3311
02:05:46,550 --> 02:05:45,199
which whereabouts

3312
02:05:47,589 --> 02:05:46,560
you are in the membrane and how much

3313
02:05:50,069 --> 02:05:47,599

interaction you've done with the

3314
02:05:52,470 --> 02:05:50,079
occurrence such as nitrate and nitrite

3315
02:05:55,270 --> 02:05:52,480
uh but uh

3316
02:05:58,229 --> 02:05:55,280
what we say is that of course i believe

3317
02:06:00,950 --> 02:05:58,239
even the pony deposit in southern

3318
02:06:03,990 --> 02:06:00,960
caledonia south caledonia has brucite

3319
02:06:05,750 --> 02:06:04,000
being precipitated at to this day

3320
02:06:07,109 --> 02:06:05,760
at that alkaline vent

3321
02:06:09,830 --> 02:06:07,119
and what we would say is there would be

3322
02:06:11,830 --> 02:06:09,840
enough iron in the early ocean to

3323
02:06:14,870 --> 02:06:11,840
give you bruce light

3324
02:06:17,189 --> 02:06:14,880
uh at the precipitate where the alka the

3325
02:06:19,510 --> 02:06:17,199
acidic ocean would meet the alkaline

3326
02:06:21,990 --> 02:06:19,520
vent and as an excuse for saying that or

3327
02:06:24,069 --> 02:06:22,000
a suggestion for saying that uh steve

3328
02:06:26,390 --> 02:06:24,079
moy just and gustaf iranius pointed out

3329
02:06:28,470 --> 02:06:26,400
a long time ago that probably all

3330
02:06:31,109 --> 02:06:28,480
abandoned iron formations of the

3331
02:06:33,589 --> 02:06:31,119
archaean and the early protozoa were all

3332
02:06:36,629 --> 02:06:33,599
um originally green rust that that was

3333
02:06:38,229 --> 02:06:36,639
the major uh precipitate anyway on the

3334
02:06:38,950 --> 02:06:38,239
early ocean and we would say that would

3335
02:06:40,310 --> 02:06:38,960
be

3336
02:06:42,149 --> 02:06:40,320
a very sp

3337
02:06:44,470 --> 02:06:42,159
particular at an alkaline vent of course

3338
02:06:46,629 --> 02:06:44,480

where it would be irresistibly dumped in

3339
02:06:48,709 --> 02:06:46,639
in places after all bruce light so bruce

3340
02:06:50,629 --> 02:06:48,719
i today in those days it would be a

3341
02:06:51,350 --> 02:06:50,639
brewside lightman molecule but it would

3342
02:06:54,470 --> 02:06:51,360
be

3343
02:06:56,229 --> 02:06:54,480
uh probably ferrous to ferric high ratio

3344
02:06:58,790 --> 02:06:56,239
but but as soon as the nitrate comes to

3345
02:07:00,790 --> 02:06:58,800
bear then it can go to ferric uh and in

3346
02:07:03,430 --> 02:07:00,800
fact it so long as it's well protected

3347
02:07:05,910 --> 02:07:03,440
by phosphate and gall away to ferric

3348
02:07:09,109 --> 02:07:05,920
uh and yet get reduced again so it's

3349
02:07:12,069 --> 02:07:09,119
just like an enzyme it can go from uh

3350
02:07:14,950 --> 02:07:12,079
almost entirely two plus to almost

3351
02:07:16,629 --> 02:07:14,960
entirely three plus and back again

3352
02:07:19,030 --> 02:07:16,639
okay that's

3353
02:07:21,589 --> 02:07:19,040
uh so uh eva stoickin

3354
02:07:24,629 --> 02:07:21,599
asked uh could you use sulfate in this

3355
02:07:27,350 --> 02:07:24,639
scenario instead of nitrate

3356
02:07:30,470 --> 02:07:27,360
uh you you can use sulfate but sulfate

3357
02:07:33,350 --> 02:07:30,480
is not reduced in this system uh

3358
02:07:34,790 --> 02:07:33,360
uh the redox contrast isn't great enough

3359
02:07:36,790 --> 02:07:34,800
uh and anyway

3360
02:07:38,950 --> 02:07:36,800
sulfate reduction is not found in the

3361
02:07:40,870 --> 02:07:38,960
last universal common ancestor it seems

3362
02:07:43,830 --> 02:07:40,880
to have been a discovery of the archaea

3363
02:07:46,229 --> 02:07:43,840

and there was then gene transfer so we

3364
02:07:48,069 --> 02:07:46,239
rather astute sulfate although we would

3365
02:07:52,069 --> 02:07:48,079
recognize that sulfate would make the

3366
02:07:54,390 --> 02:07:52,079
ocean uh as grag says from harvard uh

3367
02:07:56,390 --> 02:07:54,400
even more acidic

3368
02:07:58,790 --> 02:07:56,400
okay one more question is

3369
02:08:01,270 --> 02:07:58,800
uh kind of following up on that eve ass

3370
02:08:05,830 --> 02:08:01,280
uh how are you how do you avoid loss of

3371
02:08:10,870 --> 02:08:09,189
reduction two n2 oh well of course

3372
02:08:12,629 --> 02:08:10,880
there's going to be uh different class

3373
02:08:14,790 --> 02:08:12,639
reactions but the actual reaction that

3374
02:08:18,310 --> 02:08:14,800
mostly takes place in the green rust is

3375
02:08:28,950 --> 02:08:18,320
to is from nitrate and nitrite through

3376
02:08:33,830 --> 02:08:31,830
okay thanks very much again uh mike and

3377
02:08:36,870 --> 02:08:33,840
if anybody has any further questions you

3378
02:08:37,750 --> 02:08:36,880
can follow up with on on the chat room

3379
02:08:39,750 --> 02:08:37,760
uh

3380
02:08:41,990 --> 02:08:39,760
but we're going to move on now to the

3381
02:08:42,870 --> 02:08:42,000
pop-up talks i think we have three lined

3382
02:08:44,870 --> 02:08:42,880
up

3383
02:08:46,629 --> 02:08:44,880
and for the first one we are going to

3384
02:08:47,669 --> 02:08:46,639
zoom across the ocean to another

3385
02:08:51,189 --> 02:08:47,679
continent

3386
02:08:55,990 --> 02:08:51,199
uh back over to europe and get some uh

3387
02:08:59,990 --> 02:08:56,000
uh uh talk from uh benjamin butle uh

3388
02:09:04,790 --> 02:09:02,870

we have your slides

3389
02:09:08,470 --> 02:09:04,800
and sam if you want to double check that

3390
02:09:13,270 --> 02:09:08,480
we didn't mute him before

3391
02:09:16,790 --> 02:09:15,109
uh benjamin if you can hear us please uh

3392
02:09:19,830 --> 02:09:16,800
maybe use the chat to let us know you're

3393
02:09:22,069 --> 02:09:19,840
online um if not we can come back to you

3394
02:09:24,149 --> 02:09:22,079
once you get set up

3395
02:09:25,830 --> 02:09:24,159
yeah my phone lines are all open and

3396
02:09:27,669 --> 02:09:25,840
clear

3397
02:09:33,430 --> 02:09:27,679
okay all right we're gonna oh there he

3398
02:09:36,709 --> 02:09:35,830
okay um we have a couple extra minutes

3399
02:09:38,550 --> 02:09:36,719
we're going to wait for benjamin or

3400
02:09:40,310 --> 02:09:38,560
should we move uh

3401
02:09:42,950 --> 02:09:40,320
yeah we can do it just a moment uh for

3402
02:09:44,310 --> 02:09:42,960
benjamin and then uh what we have after

3403
02:09:47,990 --> 02:09:44,320
this we have

3404
02:09:50,950 --> 02:09:48,000
uh west swingley and um

3405
02:09:56,870 --> 02:09:50,960
slava whose last name i'm not even gonna

3406
02:09:59,589 --> 02:09:58,229
okay and then benjamin in the meantime

3407
02:10:01,189 --> 02:09:59,599
so you can start your webcam there

3408
02:10:02,709 --> 02:10:01,199
should be a start webcam button above

3409
02:10:05,830 --> 02:10:02,719
tom's head

3410
02:10:08,629 --> 02:10:07,830
the other hand

3411
02:10:11,109 --> 02:10:08,639
right

3412
02:10:24,069 --> 02:10:11,119
this region

3413
02:10:29,589 --> 02:10:26,870

yes we can hear you um click the down

3414
02:10:30,950 --> 02:10:29,599
arrow icon below to the bottom left of

3415
02:10:32,390 --> 02:10:30,960
your slides that's the best way to

3416
02:10:33,510 --> 02:10:32,400
advance

3417
02:10:37,109 --> 02:10:33,520
thanks

3418
02:10:38,709 --> 02:10:37,119
okay like this okay

3419
02:10:41,030 --> 02:10:38,719
okay so

3420
02:10:42,550 --> 02:10:41,040
the idea is to

3421
02:10:45,030 --> 02:10:42,560
explain to you how we see the

3422
02:10:46,629 --> 02:10:45,040
sympathization on mars

3423
02:10:48,950 --> 02:10:46,639
and

3424
02:10:50,870 --> 02:10:48,960
to present to you uh or we try to work

3425
02:10:53,669 --> 02:10:50,880
on symbolization on mars

3426
02:10:55,990 --> 02:10:53,679
so i will give both

3427
02:10:57,030 --> 02:10:56,000
slides to show you directly some

3428
02:10:59,430 --> 02:10:57,040
detection

3429
02:11:01,350 --> 02:10:59,440
of the protein and to show you the

3430
02:11:04,149 --> 02:11:01,360
context of our detection so here's an

3431
02:11:06,310 --> 02:11:04,159
example of the

3432
02:11:07,669 --> 02:11:06,320
of one crater where

3433
02:11:11,750 --> 02:11:07,679
we um

3434
02:11:14,709 --> 02:11:11,760
how we detect the protein and

3435
02:11:16,870 --> 02:11:14,719
it is found with inert station with a

3436
02:11:18,950 --> 02:11:16,880
lot of over iron magnesium rich

3437
02:11:21,510 --> 02:11:18,960
phyllosilicates but you can see here in

3438
02:11:23,669 --> 02:11:21,520

red and some

3439
02:11:26,229 --> 02:11:23,679
carbonate

3440
02:11:27,990 --> 02:11:26,239
and uh

3441
02:11:30,790 --> 02:11:28,000
the different sport tickets that we can

3442
02:11:34,310 --> 02:11:30,800
find mostly there are uh saponites or

3443
02:11:38,950 --> 02:11:34,320
other kinds of iron magazine um

3444
02:11:43,669 --> 02:11:38,960
spectites and some sometimes talk and so

3445
02:11:47,109 --> 02:11:45,510
sabotaging is

3446
02:11:49,430 --> 02:11:47,119
a station with iron maximum rich

3447
02:11:50,790 --> 02:11:49,440
falsificates and carbonates

3448
02:11:53,750 --> 02:11:50,800
and

3449
02:11:56,629 --> 02:11:53,760
so if we take a look at a global map of

3450
02:11:59,189 --> 02:11:56,639
detection of separating uh where it's uh

3451
02:12:01,589 --> 02:11:59,199
so it's where you can see this green uh

3452
02:12:02,310 --> 02:12:01,599
green symbol on this map

3453
02:12:08,310 --> 02:12:02,320
we

3454
02:12:11,430 --> 02:12:08,320
always detected with carbonates

3455
02:12:12,790 --> 02:12:11,440
which are the the purple simple symbol

3456
02:12:15,189 --> 02:12:12,800
in this map

3457
02:12:17,350 --> 02:12:15,199
so this is something that

3458
02:12:20,149 --> 02:12:17,360
is found every time we found saboten we

3459
02:12:21,750 --> 02:12:20,159
found those cabinets together so the

3460
02:12:23,510 --> 02:12:21,760
idea is to try to

3461
02:12:25,669 --> 02:12:23,520
um

3462
02:12:27,990 --> 02:12:25,679
is to try to understand how we can make

3463
02:12:29,430 --> 02:12:28,000

this separating and the carbonate

3464
02:12:31,189 --> 02:12:29,440
together on mars

3465
02:12:35,350 --> 02:12:31,199
and um

3466
02:12:37,270 --> 02:12:35,360
so even if we if we can uh also try to

3467
02:12:38,950 --> 02:12:37,280
understand what is

3468
02:12:41,270 --> 02:12:38,960
with this process if we can store a lot

3469
02:12:43,510 --> 02:12:41,280
of water or co2 in the crust so if we

3470
02:12:46,390 --> 02:12:43,520
can process if we can produce a lot of

3471
02:12:48,950 --> 02:12:46,400
methane and hydrogen

3472
02:12:51,030 --> 02:12:48,960
which is also really interesting i think

3473
02:12:53,109 --> 02:12:51,040
the first step about stabilization on

3474
02:12:54,229 --> 02:12:53,119
mars is to try to understand the

3475
02:12:56,390 --> 02:12:54,239
condition

3476
02:12:58,470 --> 02:12:56,400
that are needed to reproduce the same

3477
02:12:59,430 --> 02:12:58,480
neurological association that we see on

3478
02:13:01,750 --> 02:12:59,440
mars

3479
02:13:03,669 --> 02:13:01,760
and this is a work like we're trying to

3480
02:13:05,030 --> 02:13:03,679
do here at seed

3481
02:13:07,830 --> 02:13:05,040
so the

3482
02:13:10,470 --> 02:13:07,840
two methods that we we employ to do that

3483
02:13:13,669 --> 02:13:10,480
is on one way to do some geochemical

3484
02:13:15,510 --> 02:13:13,679
modeling with aq36 so this is here one

3485
02:13:16,390 --> 02:13:15,520
of the example of a result that we can

3486
02:13:19,910 --> 02:13:16,400
have

3487
02:13:22,550 --> 02:13:19,920
so here this is an interaction between a

3488
02:13:25,270 --> 02:13:22,560

fluid of pure water and a rock rich in

3489
02:13:26,790 --> 02:13:25,280
olivine so it's basically by that but uh

3490
02:13:29,430 --> 02:13:26,800
really rich in olivine 40 percent of

3491
02:13:32,069 --> 02:13:29,440
olivine 30 percent of pyroxene

3492
02:13:34,229 --> 02:13:32,079
and 40 of plagioclase we make the

3493
02:13:35,910 --> 02:13:34,239
interaction between this rock and a

3494
02:13:37,750 --> 02:13:35,920
curvature fluid at

3495
02:13:40,229 --> 02:13:37,760
200 degrees c

3496
02:13:43,189 --> 02:13:40,239
at the water track ratio of 10 and we

3497
02:13:45,910 --> 02:13:43,199
had also one bar of co2 to

3498
02:13:47,910 --> 02:13:45,920
make the carbonates and we see that the

3499
02:13:51,189 --> 02:13:47,920
separatisation occur only at low

3500
02:13:53,589 --> 02:13:51,199
temperature and we can we produce this

3501
02:13:57,109 --> 02:13:53,599
kind of medical association that we see

3502
02:13:58,950 --> 02:13:57,119
on mars the chloride sometimes the talc

3503
02:14:01,669 --> 02:13:58,960
the saponite ever carbonates together

3504
02:14:03,830 --> 02:14:01,679
with sampatine so this

3505
02:14:05,830 --> 02:14:03,840
is our first attempt to try to reproduce

3506
02:14:06,790 --> 02:14:05,840
this merely collation that we see on

3507
02:14:09,189 --> 02:14:06,800
mars

3508
02:14:10,950 --> 02:14:09,199
and the idea

3509
02:14:11,669 --> 02:14:10,960
now for the following work what we will

3510
02:14:16,550 --> 02:14:11,679
do

3511
02:14:18,470 --> 02:14:16,560
accidental studies

3512
02:14:21,750 --> 02:14:18,480
and the idea is to work in a cloth

3513
02:14:24,950 --> 02:14:21,760

system with some olivines and sometimes

3514
02:14:25,750 --> 02:14:24,960
mixed with pyroxene and glass together

3515
02:14:27,870 --> 02:14:25,760
and

3516
02:14:30,149 --> 02:14:27,880
to hit the system at

3517
02:14:32,629 --> 02:14:30,159
150 degrees c

3518
02:14:34,310 --> 02:14:32,639
and to um

3519
02:14:35,510 --> 02:14:34,320
change the atmosphere that is used

3520
02:14:36,550 --> 02:14:35,520
sometimes

3521
02:14:39,830 --> 02:14:36,560
with uh

3522
02:14:41,910 --> 02:14:39,840
without co2 or 10 percent of co2 or 100

3523
02:14:43,750 --> 02:14:41,920
of co2 at one bar

3524
02:14:46,149 --> 02:14:43,760
and to try to see

3525
02:14:47,350 --> 02:14:46,159
uh in which uh system

3526
02:14:52,709 --> 02:14:47,360
we can

3527
02:14:55,270 --> 02:14:52,719
that we see on mars so unfortunately we

3528
02:14:58,870 --> 02:14:55,280
still haven't started this uh

3529
02:15:00,870 --> 02:14:58,880
this work of experimental work but uh

3530
02:15:01,669 --> 02:15:00,880
hopefully we will start that the next

3531
02:15:04,069 --> 02:15:01,679
week

3532
02:15:05,750 --> 02:15:04,079
and maybe in a few few months i will

3533
02:15:07,589 --> 02:15:05,760
have a result to present

3534
02:15:12,709 --> 02:15:07,599
about that

3535
02:15:18,390 --> 02:15:15,830
thanks much uh benjamin uh did anybody

3536
02:15:20,069 --> 02:15:18,400
out there have a question

3537
02:15:22,069 --> 02:15:20,079
uh

3538
02:15:26,550 --> 02:15:22,079

adrian brown is interested in how much

3539
02:15:30,629 --> 02:15:26,560
how much bit uh talc gets formed uh

3540
02:15:32,229 --> 02:15:30,639
in your in your simulations there

3541
02:15:34,390 --> 02:15:32,239
okay so

3542
02:15:39,030 --> 02:15:34,400
here you can see it's in the percent of

3543
02:15:41,669 --> 02:15:39,040
mold by a percentage of mole of uh

3544
02:15:43,990 --> 02:15:41,679
of minerals so it's uh earned twenty

3545
02:15:48,790 --> 02:15:44,000
percent of target and then can be formed

3546
02:15:53,109 --> 02:15:50,709
all right great uh

3547
02:15:55,669 --> 02:15:53,119
thanks very much again ben and we will

3548
02:16:05,990 --> 02:15:55,679
now move on to the next pop-up which is

3549
02:16:09,270 --> 02:16:07,350
and what if you can hear me you can go

3550
02:16:11,270 --> 02:16:09,280
ahead and start your webcam and then

3551
02:16:13,990 --> 02:16:11,280
unmute your phone's mic

3552
02:16:16,229 --> 02:16:14,000
yeah i'm unmuted and i

3553
02:16:18,709 --> 02:16:16,239
tried to start my webcam but

3554
02:16:19,990 --> 02:16:18,719
does not seem to have worked oh sorry i

3555
02:16:22,709 --> 02:16:20,000
didn't actually make you a presenter

3556
02:16:25,109 --> 02:16:22,719
just yet um i was okay kicked off i

3557
02:16:26,390 --> 02:16:25,119
think now please go ahead

3558
02:16:28,310 --> 02:16:26,400
there you go

3559
02:16:30,069 --> 02:16:28,320
all right take it away

3560
02:16:31,270 --> 02:16:30,079
all right uh i

3561
02:16:33,190 --> 02:16:31,280
thought i would give a talk after

3562
02:16:35,669 --> 02:16:33,200
hearing matt shrank

3563
02:16:36,629 --> 02:16:35,679

mention one of my study sites yesterday

3564
02:16:39,110 --> 02:16:36,639
and

3565
02:16:41,830 --> 02:16:39,120
the the thought of course is to

3566
02:16:43,270 --> 02:16:41,840
give a talk in a serpentinization uh

3567
02:16:45,589 --> 02:16:43,280
workshop that has nothing to do with

3568
02:16:47,750 --> 02:16:45,599
serpentinization

3569
02:16:50,230 --> 02:16:47,760
this first slide is showing our study

3570
02:16:51,990 --> 02:16:50,240
site at uh calumet wetlands which is on

3571
02:16:54,870 --> 02:16:52,000
the south side of chicago

3572
02:16:56,870 --> 02:16:54,880
and we we call the surface of the moon

3573
02:16:57,750 --> 02:16:56,880
and you can kind of see why and this is

3574
02:17:28,629 --> 02:16:57,760
a

3575
02:17:33,589 --> 02:17:28,639
is showing

3576
02:17:35,190 --> 02:17:33,599
extent of this flag site which is

3577
02:17:38,549 --> 02:17:35,200
quite large and

3578
02:17:41,190 --> 02:17:38,559
as far as studies have shown meters deep

3579
02:17:42,870 --> 02:17:41,200
several tens of meters deep

3580
02:17:45,190 --> 02:17:42,880
that was filled in all the way up until

3581
02:17:47,750 --> 02:17:45,200
the mid 80s when uh industrial waste

3582
02:17:48,950 --> 02:17:47,760
dumping was not as cool as it was

3583
02:17:50,389 --> 02:17:48,960
anymore

3584
02:17:51,830 --> 02:17:50,399
and

3585
02:17:53,669 --> 02:17:51,840
you'll recognize probably some of the

3586
02:17:56,150 --> 02:17:53,679
chemistry that is going on at the site

3587
02:17:59,030 --> 02:17:56,160
and much like billy brazelton has said a

3588
02:18:02,870 --> 02:17:59,040

few times i am a microbiologist and the

3589
02:18:03,669 --> 02:18:02,880
geochemistry is done by other people

3590
02:18:05,750 --> 02:18:03,679
but

3591
02:18:07,750 --> 02:18:05,760
the the geochemistry here is relatively

3592
02:18:09,270 --> 02:18:07,760
sim similar to the serpentinizing

3593
02:18:11,669 --> 02:18:09,280
systems where you have

3594
02:18:13,830 --> 02:18:11,679
calcium or magnesium silicates

3595
02:18:15,750 --> 02:18:13,840
that are being weathered by water in

3596
02:18:16,950 --> 02:18:15,760
this case meteoric water and ultimately

3597
02:18:20,389 --> 02:18:16,960
groundwater

3598
02:18:22,549 --> 02:18:20,399
to yield a high ph system but the the

3599
02:18:24,709 --> 02:18:22,559
chemistry is very different in the

3600
02:18:26,950 --> 02:18:24,719
products coming out and that is we have

3601
02:18:28,629 --> 02:18:26,960
a high calcium fluid relatively fresh

3602
02:18:29,750 --> 02:18:28,639
water fluid

3603
02:18:32,150 --> 02:18:29,760
that has

3604
02:18:33,830 --> 02:18:32,160
high hydroxyl ions that are leading to

3605
02:18:36,469 --> 02:18:33,840
the high ph

3606
02:18:38,549 --> 02:18:36,479
and the the table on the bottom left is

3607
02:18:40,389 --> 02:18:38,559
showing some of our study sites that

3608
02:18:42,790 --> 02:18:40,399
show the

3609
02:18:44,950 --> 02:18:42,800
extent of this ph at uh

3610
02:18:47,750 --> 02:18:44,960
site two and site six for example are

3611
02:18:50,309 --> 02:18:47,760
groundwater wells where our ph is up

3612
02:18:55,349 --> 02:18:50,319
above 13 and we've seen it reach as high

3613
02:18:58,230 --> 02:18:55,359

as 13.4 and the systems are

3614
02:19:00,709 --> 02:18:58,240
as a nature of being a steel waste site

3615
02:19:02,870 --> 02:19:00,719
are loaded with a lot of metals as well

3616
02:19:05,830 --> 02:19:02,880
lead primarily is fairly high

3617
02:19:07,110 --> 02:19:05,840
and magnesium calcium are both off the

3618
02:19:11,349 --> 02:19:07,120
charts as you might expect from the

3619
02:19:15,270 --> 02:19:13,110
and just taking a look at the site

3620
02:19:17,349 --> 02:19:15,280
anybody who's been to one of the

3621
02:19:20,309 --> 02:19:17,359
terrestrial alkaline sites would

3622
02:19:22,309 --> 02:19:20,319
recognize a lot of the same features

3623
02:19:25,669 --> 02:19:22,319
here where we have a calcite

3624
02:19:27,509 --> 02:19:25,679
precipitation throughout and this is a

3625
02:19:30,150 --> 02:19:27,519
irrigation canal going through the city

3626
02:19:32,150 --> 02:19:30,160
so as such it has very steep sides

3627
02:19:34,709 --> 02:19:32,160
one of my students here from an ru

3628
02:19:36,549 --> 02:19:34,719
project that i did is excitedly

3629
02:19:38,950 --> 02:19:36,559
testing the depth of this just off the

3630
02:19:40,070 --> 02:19:38,960
shore and you can't quite see it but

3631
02:19:42,469 --> 02:19:40,080
that

3632
02:19:43,830 --> 02:19:42,479
grabber stick went about five feet deep

3633
02:19:45,750 --> 02:19:43,840
in the

3634
02:19:47,110 --> 02:19:45,760
sediment just a couple feet offshore so

3635
02:19:48,710 --> 02:19:47,120
it's very deep

3636
02:19:51,270 --> 02:19:48,720
and the

3637
02:19:52,870 --> 02:19:51,280
calcite precipitation is very reducing

3638
02:19:54,469 --> 02:19:52,880

in that we have

3639
02:19:56,950 --> 02:19:54,479
completely anoxic conditions just

3640
02:19:58,389 --> 02:19:56,960
millimeters below the surface

3641
02:20:00,230 --> 02:19:58,399
we've

3642
02:20:01,830 --> 02:20:00,240
done a lot of analysis here and

3643
02:20:03,670 --> 02:20:01,840
unfortunately haven't gotten anything

3644
02:20:05,429 --> 02:20:03,680
published yet but

3645
02:20:07,030 --> 02:20:05,439
a couple of our primary looks are at the

3646
02:20:09,750 --> 02:20:07,040
transects along this

3647
02:20:12,870 --> 02:20:09,760
system going from in the shore

3648
02:20:14,710 --> 02:20:12,880
into this calcite precipitation and also

3649
02:20:17,030 --> 02:20:14,720
on the vertical core going down through

3650
02:20:18,150 --> 02:20:17,040
the deepest layers of the anoxic

3651
02:20:20,870 --> 02:20:18,160
sediments

3652
02:20:23,510 --> 02:20:20,880
and without going too in depth on this

3653
02:20:25,910 --> 02:20:23,520
what we see is very similar to what

3654
02:20:28,070 --> 02:20:25,920
billy and matt have described and darcy

3655
02:20:30,790 --> 02:20:28,080
to some extent as well have described in

3656
02:20:32,550 --> 02:20:30,800
similar natural systems where we have

3657
02:20:34,230 --> 02:20:32,560
large concentrations of beta

3658
02:20:36,950 --> 02:20:34,240
proteobacteria

3659
02:20:38,790 --> 02:20:36,960
primarily relatives of the serpentimonus

3660
02:20:39,830 --> 02:20:38,800
and hydrogen ophega that was mentioned

3661
02:20:42,070 --> 02:20:39,840
before

3662
02:20:43,190 --> 02:20:42,080
in the arabic sediments and that

3663
02:20:46,070 --> 02:20:43,200

gradient

3664
02:20:48,790 --> 02:20:46,080
transitioning to anoxic system that is

3665
02:20:50,070 --> 02:20:48,800
dominated by firmicutes and that's the

3666
02:20:51,590 --> 02:20:50,080
bright red that you see on the right

3667
02:20:53,190 --> 02:20:51,600
hand of that chart

3668
02:20:54,710 --> 02:20:53,200
where we have

3669
02:20:56,309 --> 02:20:54,720
heavy firm acute populations in the

3670
02:20:59,590 --> 02:20:56,319
deepest layers

3671
02:21:01,750 --> 02:20:59,600
and we're looking at metagenomics and

3672
02:21:04,950 --> 02:21:01,760
16s ribosomal surveys

3673
02:21:06,950 --> 02:21:04,960
to see exactly what organisms are there

3674
02:21:09,349 --> 02:21:06,960
and in the case of some of these doing

3675
02:21:11,670 --> 02:21:09,359
assemblies from the metagenomes in order

3676
02:21:14,309 --> 02:21:11,680
to analyze more of how they're surviving

3677
02:21:16,870 --> 02:21:14,319
in this high ph as matt said this is an

3678
02:21:18,550 --> 02:21:16,880
open question nobody really knows why or

3679
02:21:20,630 --> 02:21:18,560
how these organisms can survive in these

3680
02:21:23,110 --> 02:21:20,640
systems and then the question of whether

3681
02:21:25,110 --> 02:21:23,120
they're thriving or merely getting by

3682
02:21:26,870 --> 02:21:25,120
and that's basically it so i'm happy to

3683
02:21:29,990 --> 02:21:26,880
take questions i see darcy's got a

3684
02:21:34,550 --> 02:21:31,830
yeah darcy sent in the question okay

3685
02:21:35,750 --> 02:21:34,560
what what happens at depths between 25

3686
02:21:38,630 --> 02:21:35,760
and 30.

3687
02:21:41,910 --> 02:21:38,640
is that the aerobic anaerobic interface

3688
02:21:43,750 --> 02:21:41,920

so it looks like quite a change in the

3689
02:21:46,389 --> 02:21:43,760
microbial populations

3690
02:21:47,910 --> 02:21:46,399
yeah for sure and the the line that i've

3691
02:21:50,469 --> 02:21:47,920
drawn there is the

3692
02:21:53,030 --> 02:21:50,479
the rough shoreline uh and the shoreline

3693
02:21:56,230 --> 02:21:53,040
of course changes with the

3694
02:21:58,230 --> 02:21:56,240
the water uh level as well and so that

3695
02:22:00,150 --> 02:21:58,240
level really does seem to be the

3696
02:22:01,030 --> 02:22:00,160
transition where you go from

3697
02:22:13,110 --> 02:22:01,040
a

3698
02:22:15,510 --> 02:22:13,120
is

3699
02:22:17,190 --> 02:22:15,520
where we see the calcite precipitating

3700
02:22:19,429 --> 02:22:17,200
and everything above that level is

3701
02:22:23,030 --> 02:22:19,439
basically too disrupted by the flow of

3702
02:22:25,190 --> 02:22:23,040
this river so that there's a constant a

3703
02:22:26,550 --> 02:22:25,200
few centimeters of depth of water over

3704
02:22:29,990 --> 02:22:26,560
the top of this

3705
02:22:33,750 --> 02:22:31,670
uh and that one uh to answer her other

3706
02:22:35,670 --> 02:22:33,760
question that one's a horizontal core

3707
02:22:38,150 --> 02:22:35,680
uh or a horizontal transect rather

3708
02:22:39,750 --> 02:22:38,160
taking five centimeter increments and we

3709
02:22:42,710 --> 02:22:39,760
do have a core

3710
02:22:44,550 --> 02:22:42,720
that looks very similar to this but the

3711
02:22:46,790 --> 02:22:44,560
the top layers of the core when we get

3712
02:22:49,270 --> 02:22:46,800
out into the water don't actually look a

3713
02:22:51,270 --> 02:22:49,280

lot like the shoreline where we don't

3714
02:22:52,710 --> 02:22:51,280
have a huge concentration of these beta

3715
02:22:54,870 --> 02:22:52,720
proteobacteria

3716
02:22:57,590 --> 02:22:54,880
in the upper water column

3717
02:23:00,790 --> 02:22:57,600
like we do on the shore it seems to be a

3718
02:23:05,510 --> 02:23:03,190
and uh billy uh just commented there

3719
02:23:07,670 --> 02:23:05,520
that that it's interesting to see that

3720
02:23:09,750 --> 02:23:07,680
we have this very similar microbial

3721
02:23:12,309 --> 02:23:09,760
populations to what we're observing in

3722
02:23:14,230 --> 02:23:12,319
the uh serpentinite system so

3723
02:23:16,550 --> 02:23:14,240
yeah the geochemistry is

3724
02:23:19,030 --> 02:23:16,560
similar in some ways in the ph of course

3725
02:23:21,910 --> 02:23:19,040
and some of the

3726
02:23:24,309 --> 02:23:21,920
anions and cations but

3727
02:23:26,469 --> 02:23:24,319
there are some major differences and

3728
02:23:29,349 --> 02:23:26,479
we're really interested to see what this

3729
02:23:30,790 --> 02:23:29,359
means in terms of biogeography and also

3730
02:23:32,790 --> 02:23:30,800
in terms of

3731
02:23:34,309 --> 02:23:32,800
survivability for the

3732
02:23:36,550 --> 02:23:34,319
iph systems

3733
02:23:39,270 --> 02:23:36,560
do you know if any if the

3734
02:23:42,630 --> 02:23:39,280
the uh the slag there is it driving any

3735
02:23:44,150 --> 02:23:42,640
kind of like hydrogen production or

3736
02:23:46,389 --> 02:23:44,160
we don't know and

3737
02:23:47,270 --> 02:23:46,399
yeah and this is a limitation of my own

3738
02:23:49,190 --> 02:23:47,280

uh

3739
02:23:51,830 --> 02:23:49,200
crappy geochemistry

3740
02:23:55,270 --> 02:23:51,840
that we've not done some of that uh core

3741
02:23:57,670 --> 02:23:55,280
geochemistry on methane and hydrogen

3742
02:24:00,469 --> 02:23:57,680
in a lot of the summer seasons we do see

3743
02:24:03,349 --> 02:24:00,479
bubbling coming up through these

3744
02:24:05,429 --> 02:24:03,359
precipitates and we've tried to do some

3745
02:24:06,950 --> 02:24:05,439
studies on methane production but we

3746
02:24:08,950 --> 02:24:06,960
have a lot of sulfides in the

3747
02:24:10,950 --> 02:24:08,960
environment and the sulfides

3748
02:24:13,429 --> 02:24:10,960
were cocking up some of our

3749
02:24:15,429 --> 02:24:13,439
machinery

3750
02:24:17,910 --> 02:24:15,439
also i was curious to know like what

3751
02:24:21,110 --> 02:24:17,920
what was the highest ph that you

3752
02:24:22,389 --> 02:24:21,120
you've gotten like dna out of it

3753
02:24:24,389 --> 02:24:22,399
uh we get

3754
02:24:25,349 --> 02:24:24,399
yeah we get dna out of everything and

3755
02:24:27,590 --> 02:24:25,359
the

3756
02:24:29,670 --> 02:24:27,600
highest ph that we've measured is in

3757
02:24:31,910 --> 02:24:29,680
both in the groundwater wells and in

3758
02:24:33,670 --> 02:24:31,920
some of the springs so there are just

3759
02:24:35,030 --> 02:24:33,680
little groundwater springs that leak out

3760
02:24:36,950 --> 02:24:35,040
into the slag

3761
02:24:38,469 --> 02:24:36,960
the the big slag pile is basically

3762
02:24:39,750 --> 02:24:38,479
behind the student that you see in the

3763
02:24:41,270 --> 02:24:39,760

image here

3764
02:24:45,510 --> 02:24:41,280
and the springs that come out of those

3765
02:24:47,990 --> 02:24:47,270
all right all right great thank you very

3766
02:24:51,429 --> 02:24:48,000
much

3767
02:24:53,510 --> 02:24:51,439
uh we'll go to our last pop-up now uh

3768
02:24:57,110 --> 02:24:53,520
and we're going to slava and i will let

3769
02:25:00,790 --> 02:24:57,120
him introduce himself

3770
02:25:03,030 --> 02:25:00,800
uh hello everybody can you hear me

3771
02:25:05,590 --> 02:25:03,040
yes again

3772
02:25:11,590 --> 02:25:05,600
i'm looking where to start my okay as

3773
02:25:15,910 --> 02:25:14,070
okay can you hear can you see me

3774
02:25:17,590 --> 02:25:15,920
yep we can see and hear you uh just take

3775
02:25:19,910 --> 02:25:17,600
it away you can control your slides by

3776
02:25:22,389 --> 02:25:19,920
clicking the down arrow icon located to

3777
02:25:24,630 --> 02:25:22,399
the bottom left of your slides there

3778
02:25:27,429 --> 02:25:24,640
okay okay i see great

3779
02:25:30,389 --> 02:25:27,439
so green good evening from paris

3780
02:25:32,389 --> 02:25:30,399
uh my name is gashislav narik

3781
02:25:35,750 --> 02:25:32,399
and thank you for this opportunity to

3782
02:25:38,870 --> 02:25:35,760
present our work and thank you also for

3783
02:25:40,710 --> 02:25:38,880
organization of this workshop in form of

3784
02:25:52,389 --> 02:25:40,720
a

3785
02:25:55,830 --> 02:25:52,399
here's one picture

3786
02:25:57,910 --> 02:25:55,840
of um atlantic also of the usa

3787
02:26:00,790 --> 02:25:57,920
and there are a lot of uh interesting

3788
02:26:02,469 --> 02:26:00,800

formations on its surface so called

3789
02:26:04,309 --> 02:26:02,479
carolina bays

3790
02:26:05,950 --> 02:26:04,319
there are a lot of them

3791
02:26:09,670 --> 02:26:05,960
about

3792
02:26:12,550 --> 02:26:09,680
500 or thousands of these structures

3793
02:26:15,030 --> 02:26:12,560
these are oval depressions shallow

3794
02:26:17,750 --> 02:26:15,040
depressions on the surface

3795
02:26:19,670 --> 02:26:17,760
and they range in size from 100 meters

3796
02:26:21,830 --> 02:26:19,680
to several kilometers

3797
02:26:24,230 --> 02:26:21,840
and we tested them

3798
02:26:26,469 --> 02:26:24,240
for presence of hydrogen gas

3799
02:26:28,630 --> 02:26:26,479
and we discovered that

3800
02:26:31,670 --> 02:26:28,640
subsoil layers

3801
02:26:33,270 --> 02:26:31,680
inside of those bays contain molecular

3802
02:26:36,309 --> 02:26:33,280
molecular hydrogen

3803
02:26:37,750 --> 02:26:36,319
while outside there is no hydrogen

3804
02:26:38,790 --> 02:26:37,760
at all

3805
02:26:41,429 --> 02:26:38,800
and

3806
02:26:43,349 --> 02:26:41,439
we started in details

3807
02:26:45,670 --> 02:26:43,359
this discovery and we published our

3808
02:26:46,630 --> 02:26:45,680
results recently in a peer-reviewed

3809
02:26:49,590 --> 02:26:46,640
journal

3810
02:26:51,030 --> 02:26:49,600
so i will show you several examples now

3811
02:26:54,070 --> 02:26:51,040
here is one

3812
02:26:57,429 --> 02:26:54,080
uh average size bay

3813
02:26:59,270 --> 02:26:57,439

and the red line shows the profile

3814
02:27:03,110 --> 02:26:59,280
on which we measure its

3815
02:27:05,190 --> 02:27:03,120
hydrogen in subsoil gas and the green

3816
02:27:06,550 --> 02:27:05,200
graph for green line shows hydrogen

3817
02:27:08,550 --> 02:27:06,560
concentrations

3818
02:27:10,150 --> 02:27:08,560
and you see once we enter

3819
02:27:14,070 --> 02:27:10,160
inside

3820
02:27:16,230 --> 02:27:14,080
the bay they increase

3821
02:27:18,710 --> 02:27:16,240
many orders of magnitude and once we

3822
02:27:21,190 --> 02:27:18,720
leave one once we go outside of the bay

3823
02:27:22,790 --> 02:27:21,200
there is no hydrogen at all

3824
02:27:24,630 --> 02:27:22,800
and

3825
02:27:27,030 --> 02:27:24,640
this is the same place

3826
02:27:28,870 --> 02:27:27,040
showed on liver

3827
02:27:32,469 --> 02:27:28,880
image showing

3828
02:27:32,800 --> 02:27:32,479
elevation in artificial colors

3829
02:27:34,309 --> 02:27:32,810
and

3830
02:27:36,230 --> 02:27:34,319
[Music]

3831
02:27:37,750 --> 02:27:36,240
here's another place

3832
02:27:39,429 --> 02:27:37,760
where we tested

3833
02:27:42,389 --> 02:27:39,439
for hydrogen

3834
02:27:44,469 --> 02:27:42,399
the first one was in north american

3835
02:27:47,270 --> 02:27:44,479
continent this one in

3836
02:27:51,110 --> 02:27:47,280
europe european part of russia

3837
02:27:53,830 --> 02:27:51,120
and just near ukrainian border where i'm

3838
02:27:55,990 --> 02:27:53,840

originally from from ukraine

3839
02:27:59,030 --> 02:27:56,000
and here we

3840
02:28:01,590 --> 02:27:59,040
studied one large

3841
02:28:03,670 --> 02:28:01,600
depression on the surface we the red

3842
02:28:06,469 --> 02:28:03,680
line represents um

3843
02:28:09,510 --> 02:28:06,479
the profile were of measures

3844
02:28:10,830 --> 02:28:09,520
and the on the right side

3845
02:28:14,230 --> 02:28:10,840
you can

3846
02:28:16,150 --> 02:28:14,240
see sure how to make the arrow but on

3847
02:28:18,070 --> 02:28:16,160
the right graph you can see the hydrogen

3848
02:28:19,110 --> 02:28:18,080
concentration which corresponds to the

3849
02:28:23,670 --> 02:28:19,120
red

3850
02:28:26,710 --> 02:28:23,680
profile line and once we enter into this

3851
02:28:27,990 --> 02:28:26,720
depression concentration increases

3852
02:28:30,550 --> 02:28:28,000
abruptly

3853
02:28:32,950 --> 02:28:30,560
and on the lower part lower left part

3854
02:28:35,429 --> 02:28:32,960
you see the

3855
02:28:38,389 --> 02:28:35,439
elevation profile which corresponds also

3856
02:28:41,270 --> 02:28:38,399
to hydrogen concentration

3857
02:28:41,990 --> 02:28:41,280
of course we verify that this hydrogen

3858
02:28:43,990 --> 02:28:42,000
is

3859
02:28:46,389 --> 02:28:44,000
not superficial because it was first

3860
02:28:49,910 --> 02:28:46,399
assumption assumption

3861
02:28:53,349 --> 02:28:49,920
uh we made a lot of tests to to see

3862
02:28:55,910 --> 02:28:53,359
where it comes from and um

3863
02:28:58,389 --> 02:28:55,920

we have evidence that it's of this

3864
02:29:01,190 --> 02:28:58,399
hydrogen is of deep origin

3865
02:29:02,790 --> 02:29:01,200
uh because we have um

3866
02:29:05,910 --> 02:29:02,800
results from

3867
02:29:09,270 --> 02:29:05,920
wells drilled nearby of

3868
02:29:10,870 --> 02:29:09,280
such depressions which are very

3869
02:29:14,070 --> 02:29:10,880
hydrogenated

3870
02:29:17,110 --> 02:29:14,080
there are tens of percent sometimes

3871
02:29:21,190 --> 02:29:17,120
more than it's a major gas

3872
02:29:24,790 --> 02:29:21,200
also recently we tested for other fluids

3873
02:29:25,910 --> 02:29:24,800
uh tracers like helium or mercury and we

3874
02:29:29,110 --> 02:29:25,920
also

3875
02:29:31,510 --> 02:29:29,120
uh find that they are distribution cores

3876
02:29:33,750 --> 02:29:31,520
to hydrogen so their concentrations are

3877
02:29:35,030 --> 02:29:33,760
very high inside of these places these

3878
02:29:37,270 --> 02:29:35,040
locations

3879
02:29:40,870 --> 02:29:37,280
and based on data we

3880
02:29:42,950 --> 02:29:40,880
obtained from field tests we estimated

3881
02:29:44,389 --> 02:29:42,960
daily flows from these

3882
02:29:46,469 --> 02:29:44,399
places and they're

3883
02:29:47,429 --> 02:29:46,479
actually very high in some locations

3884
02:29:52,230 --> 02:29:47,439
it's

3885
02:29:53,830 --> 02:29:52,240
uh our numbers is up to 21 000

3886
02:29:57,910 --> 02:29:53,840
cubic meters

3887
02:30:00,950 --> 02:29:57,920
per day which is very high comparable to

3888
02:30:05,349 --> 02:30:01,830

from

3889
02:30:07,190 --> 02:30:05,359
natural gas wells and we publish those

3890
02:30:09,990 --> 02:30:07,200
results too

3891
02:30:11,429 --> 02:30:10,000
and i will show you one more example

3892
02:30:13,750 --> 02:30:11,439
there is the very

3893
02:30:15,910 --> 02:30:13,760
small structure only 100 meters in

3894
02:30:18,389 --> 02:30:15,920
diameter and there are three

3895
02:30:20,309 --> 02:30:18,399
profiles crossing it and you see the

3896
02:30:21,750 --> 02:30:20,319
same distribution once we're inside we

3897
02:30:24,230 --> 02:30:21,760
have this

3898
02:30:25,349 --> 02:30:24,240
very high hydrogen content

3899
02:30:28,389 --> 02:30:25,359
so

3900
02:30:31,349 --> 02:30:28,399
we believe that

3901
02:30:32,630 --> 02:30:31,359
those dislocations are some kind of

3902
02:30:33,750 --> 02:30:32,640
chimneys

3903
02:30:36,230 --> 02:30:33,760
uh

3904
02:30:38,630 --> 02:30:36,240
used by fluids

3905
02:30:40,550 --> 02:30:38,640
like a pacifier for fluids

3906
02:30:42,630 --> 02:30:40,560
uh probably it

3907
02:30:44,550 --> 02:30:42,640
has a relationship with hydrogen because

3908
02:30:47,990 --> 02:30:44,560
hydrogen is directed yes it may have

3909
02:30:50,309 --> 02:30:48,000
reacted with minerals creating porosity

3910
02:30:51,990 --> 02:30:50,319
and the porosity collapse with time and

3911
02:30:55,349 --> 02:30:52,000
that's why we see depressions in the

3912
02:31:00,550 --> 02:30:58,790
hydrogen concentrations and other

3913
02:31:03,110 --> 02:31:00,560

gases as well

3914
02:31:04,389 --> 02:31:03,120
and um so we tested

3915
02:31:06,550 --> 02:31:04,399
these um

3916
02:31:07,990 --> 02:31:06,560
many of them many locations

3917
02:31:09,670 --> 02:31:08,000
unfortunately i don't have enough time

3918
02:31:12,550 --> 02:31:09,680
to present everything

3919
02:31:15,110 --> 02:31:12,560
done so but um

3920
02:31:17,030 --> 02:31:15,120
our

3921
02:31:18,630 --> 02:31:17,040
collaborators started

3922
02:31:19,830 --> 02:31:18,640
for hydrogen on

3923
02:31:21,990 --> 02:31:19,840
in

3924
02:31:23,429 --> 02:31:22,000
south america so we have some three

3925
02:31:26,630 --> 02:31:23,439
continents

3926
02:31:29,510 --> 02:31:26,640
now where these locations are present

3927
02:31:31,510 --> 02:31:29,520
and the numbers um of hydrogen are very

3928
02:31:34,550 --> 02:31:31,520
very impressive actually and

3929
02:31:35,830 --> 02:31:34,560
we decided why not to

3930
02:31:38,389 --> 02:31:35,840
we wanted to know

3931
02:31:41,429 --> 02:31:38,399
more and uh to know more we need to

3932
02:31:42,389 --> 02:31:41,439
drill in those places so we created

3933
02:31:45,990 --> 02:31:42,399
a

3934
02:31:48,710 --> 02:31:46,000
i'm

3935
02:31:51,510 --> 02:31:48,720
working on now and we are planning to

3936
02:31:52,389 --> 02:31:51,520
make a deep exploratory drill into one

3937
02:31:55,510 --> 02:31:52,399
of these

3938
02:31:57,030 --> 02:31:55,520

locations we select it in the united

3939
02:31:58,270 --> 02:31:57,040
states

3940
02:31:59,910 --> 02:31:58,280
and this

3941
02:32:02,550 --> 02:31:59,920
[Music]

3942
02:32:05,750 --> 02:32:02,560
very good time because just three years

3943
02:32:07,110 --> 02:32:05,760
ago in mali in africa there was a proof

3944
02:32:09,429 --> 02:32:07,120
of concept

3945
02:32:12,550 --> 02:32:09,439
one well

3946
02:32:13,910 --> 02:32:12,560
one drilled well started to produce 98

3947
02:32:16,070 --> 02:32:13,920
pure hydrogen

3948
02:32:19,670 --> 02:32:16,080
and they use this hydrogen to make

3949
02:32:22,309 --> 02:32:19,680
electricity to supply for local village

3950
02:32:24,710 --> 02:32:22,319
and uh so we want to do then

3951
02:32:26,150 --> 02:32:24,720
something this of the same nature but in

3952
02:32:27,990 --> 02:32:26,160
united states

3953
02:32:30,150 --> 02:32:28,000
and um

3954
02:32:32,389 --> 02:32:30,160
therefore

3955
02:32:34,230 --> 02:32:32,399
we're working on this project now and

3956
02:32:38,389 --> 02:32:34,240
because our team

3957
02:32:40,389 --> 02:32:38,399
is are mainly scientists we're all

3958
02:32:41,830 --> 02:32:40,399
researchers and we want to do a lot of

3959
02:32:44,230 --> 02:32:41,840
research

3960
02:32:45,670 --> 02:32:44,240
connected with this project and

3961
02:32:47,270 --> 02:32:45,680
that's why we're looking for

3962
02:32:50,309 --> 02:32:47,280
collaborators

3963
02:32:53,830 --> 02:32:50,319

so for example uh we want to

3964
02:32:56,469 --> 02:32:53,840
know what microorganisms are living

3965
02:32:58,630 --> 02:32:56,479
associated with these places

3966
02:33:01,190 --> 02:32:58,640
uh maybe it will be possible to start

3967
02:33:03,590 --> 02:33:01,200
from surface tests and then when we will

3968
02:33:05,670 --> 02:33:03,600
have deep samples to to study

3969
02:33:07,910 --> 02:33:05,680
what's going on inside

3970
02:33:09,110 --> 02:33:07,920
or for example

3971
02:33:12,070 --> 02:33:09,120
um

3972
02:33:14,070 --> 02:33:12,080
there is a need to study reactivity

3973
02:33:15,590 --> 02:33:14,080
between

3974
02:33:17,190 --> 02:33:15,600
rocks and

3975
02:33:18,950 --> 02:33:17,200
hydrogen because there are a lot of

3976
02:33:20,790 --> 02:33:18,960
research and going

3977
02:33:23,190 --> 02:33:20,800
what we've seen today on

3978
02:33:26,389 --> 02:33:23,200
production of hydrogen from minerals but

3979
02:33:28,790 --> 02:33:26,399
not enough actually of what how hydrogen

3980
02:33:31,910 --> 02:33:28,800
reacts with with other minerals

3981
02:33:34,630 --> 02:33:31,920
so i'm invite you to contact me if you

3982
02:33:36,389 --> 02:33:34,640
have an interest in please check your

3983
02:33:38,550 --> 02:33:36,399
references and if you have any questions

3984
02:33:39,990 --> 02:33:38,560
i will be happy to answer thank you once

3985
02:33:42,710 --> 02:33:40,000
again for this opportunity to the

3986
02:33:44,870 --> 02:33:42,720
president it's very exciting thank you

3987
02:33:48,309 --> 02:33:44,880
okay thank you very much uh could you uh

3988
02:33:50,309 --> 02:33:48,319

pronounce your first name again

3989
02:33:52,309 --> 02:33:50,319
my first name is vyashistva but

3990
02:33:54,950 --> 02:33:52,319
everybody calls me slava it's more

3991
02:33:57,349 --> 02:33:54,960
simple just please call me yeah it's

3992
02:33:59,110 --> 02:33:57,359
easier easier for us to handle right uh

3993
02:34:00,630 --> 02:33:59,120
thanks a lot uh so do you do you know

3994
02:34:04,550 --> 02:34:00,640
anything about the geology that

3995
02:34:10,550 --> 02:34:08,230
these are sediments and

3996
02:34:13,270 --> 02:34:10,560
not very thick in

3997
02:34:16,469 --> 02:34:13,280
atlantic coast there are about

3998
02:34:18,309 --> 02:34:16,479
100 meters of

3999
02:34:21,110 --> 02:34:18,319
clays and sand

4000
02:34:25,030 --> 02:34:21,120
and in the case of

4001
02:34:35,590 --> 02:34:25,040
russia there are 600 meters of sediments

4002
02:34:38,870 --> 02:34:37,190
sorry uh

4003
02:34:40,230 --> 02:34:38,880
we did have one question here on the web

4004
02:34:44,309 --> 02:34:40,240
uh

4005
02:34:45,990 --> 02:34:44,319
you it sounds like you're not sure of

4006
02:34:48,150 --> 02:34:46,000
the source of the hydrogen

4007
02:34:51,590 --> 02:34:48,160
uh and do you think this was different

4008
02:34:53,030 --> 02:34:51,600
than the source of hydrogen that uh is

4009
02:34:54,630 --> 02:34:53,040
that uh

4010
02:34:58,389 --> 02:34:54,640
has been proposed for like deep

4011
02:35:01,429 --> 02:34:58,399
serpentization sources and and uh would

4012
02:35:04,070 --> 02:35:01,439
do you think this would affect uh

4013
02:35:07,190 --> 02:35:04,080

uh the estimates of the the global

4014
02:35:11,830 --> 02:35:10,230
yes definitely because there are

4015
02:35:14,790 --> 02:35:11,840
a lot of these structures around the

4016
02:35:17,349 --> 02:35:14,800
globe and

4017
02:35:19,590 --> 02:35:17,359
the this will definitely affect the

4018
02:35:21,910 --> 02:35:19,600
global estimates for region production

4019
02:35:23,990 --> 02:35:21,920
is something that we're working on now

4020
02:35:26,710 --> 02:35:24,000
and it will increase at least by one

4021
02:35:28,950 --> 02:35:26,720
order of magnitude estimates

4022
02:35:31,590 --> 02:35:28,960
and probably even more but we need to do

4023
02:35:35,429 --> 02:35:31,600
more more research to to understand and

4024
02:35:38,469 --> 02:35:35,439
concerning the origin we have two main

4025
02:35:40,389 --> 02:35:38,479
approaches now one classical approach is

4026
02:35:44,220 --> 02:35:40,399
for serpentinization

4027
02:35:45,590 --> 02:35:44,230
and one is more um

4028
02:35:47,750 --> 02:35:45,600
[Music]

4029
02:35:50,070 --> 02:35:47,760
marginalized approach

4030
02:35:53,590 --> 02:35:50,080
that this come this hydrogen comes from

4031
02:35:55,910 --> 02:35:53,600
mental mental degassing and it was this

4032
02:35:58,710 --> 02:35:55,920
is a primordial hydrogen stored

4033
02:36:01,349 --> 02:35:58,720
in uh in earth inside of the earth's uh

4034
02:36:05,030 --> 02:36:01,359
sensing formation okay and and one other

4035
02:36:06,630 --> 02:36:05,040
question uh when i also had in you uh i

4036
02:36:09,349 --> 02:36:06,640
don't recall if you mentioned how you're

4037
02:36:13,110 --> 02:36:09,359
doing these uh hydrogen measurements and

4038
02:36:14,870 --> 02:36:13,120

can you detect other gases with the same

4039
02:36:17,349 --> 02:36:14,880
same approach

4040
02:36:19,830 --> 02:36:17,359
yes we

4041
02:36:23,110 --> 02:36:19,840
we make a shallow hole

4042
02:36:25,590 --> 02:36:23,120
in the in the soil using the steel steel

4043
02:36:27,910 --> 02:36:25,600
rod we push the steel rod into the soil

4044
02:36:30,630 --> 02:36:27,920
and we take it out and we put

4045
02:36:33,429 --> 02:36:30,640
immediately we plug immediately

4046
02:36:34,950 --> 02:36:33,439
with the plug connected to portable

4047
02:36:36,469 --> 02:36:34,960
detectors

4048
02:36:39,510 --> 02:36:36,479
so we measure

4049
02:36:41,110 --> 02:36:39,520
this way in the field and then we sample

4050
02:36:43,270 --> 02:36:41,120
uh in

4051
02:36:46,230 --> 02:36:43,280
different types of containers and we

4052
02:36:48,070 --> 02:36:46,240
make analysis in laboratory and gas

4053
02:36:50,950 --> 02:36:48,080
chromatographs to confirm our field

4054
02:36:53,349 --> 02:36:50,960
results

4055
02:36:54,389 --> 02:36:53,359
all right thank you very much slava uh

4056
02:36:55,510 --> 02:36:54,399
so

4057
02:36:57,110 --> 02:36:55,520
um

4058
02:36:59,110 --> 02:36:57,120
we do have a couple of minutes left if

4059
02:37:01,510 --> 02:36:59,120
there's any other persisting questions

4060
02:37:06,469 --> 02:37:01,520
out there that anybody had for

4061
02:37:07,830 --> 02:37:06,479
any of the speakers today if uh

4062
02:37:12,070 --> 02:37:07,840
there's any

4063
02:37:16,070 --> 02:37:14,309

anybody else have any other comments or

4064
02:37:20,469 --> 02:37:16,080
contributions they wanted to

4065
02:37:23,110 --> 02:37:21,670
right well

4066
02:37:24,710 --> 02:37:23,120
sounds like uh

4067
02:37:27,190 --> 02:37:24,720
that's it so why don't we wrap things up

4068
02:37:29,590 --> 02:37:27,200
for today and and remember tomorrow

4069
02:37:33,110 --> 02:37:29,600
we are going to reconvene at the same

4070
02:37:35,110 --> 02:37:33,120
bat time same bat channel and uh

4071
02:37:37,030 --> 02:37:35,120
be talking more about uh things having

4072
02:37:37,830 --> 02:37:37,040
to do with planetary

4073
02:37:44,710 --> 02:37:37,840
uh

4074
02:37:47,750 --> 02:37:44,720
hopefully

4075
02:37:52,950 --> 02:37:51,349
we're posting the survey link uh so we

4076
02:37:55,110 --> 02:37:52,960
want your feedback we'll leave this

4077
02:37:56,389 --> 02:37:55,120
meeting open a little bit longer than we

4078
02:37:58,790 --> 02:37:56,399
did yesterday we accidentally shut

4079
02:38:00,469 --> 02:37:58,800
everyone out so uh you can continue

4080
02:38:02,790 --> 02:38:00,479
posting questions in the chat

4081
02:38:04,469 --> 02:38:02,800
and we want your feedback so

4082
02:38:06,870 --> 02:38:04,479
go to the link there