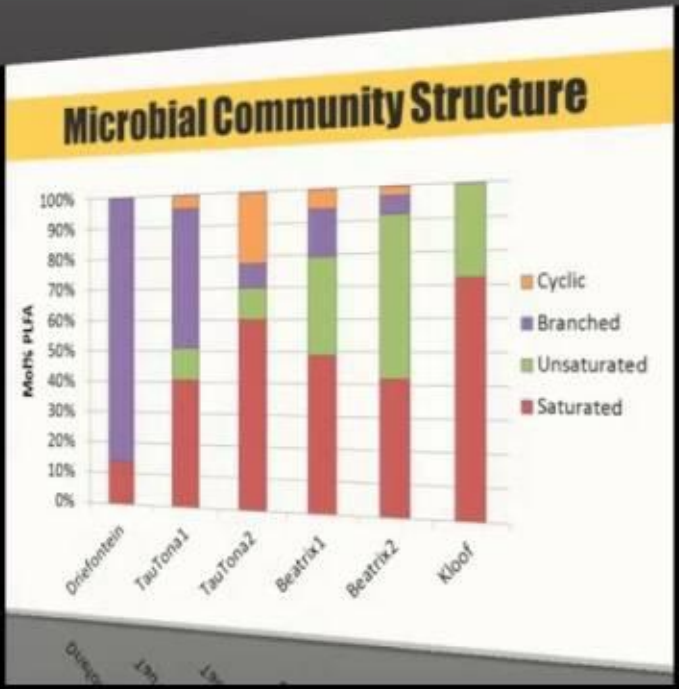
Microbial Community Structure
Mol% PLFA
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Cyclic
Branched
Unsaturated
Saturated
Onefontein
TauTona1
TauTona2
Beatrix1
Beatrix2
Kloof

1
00:00:09,669 --> 00:00:08,150
today i'm going to talk about microbial

2
00:00:11,749 --> 00:00:09,679
bowel signatures in the deep terrestrial

3
00:00:13,830 --> 00:00:11,759
subsurface and i'll be specifically

4
00:00:16,550 --> 00:00:13,840
focusing on the approaches of plfa

5
00:00:21,189 --> 00:00:16,560
analysis and carbon isotope analyses for

6
00:00:24,950 --> 00:00:23,109
so when we talk about life in the deep

7
00:00:26,870 --> 00:00:24,960
terrestrial subsurface we're talking

8
00:00:28,790 --> 00:00:26,880
specifically about life in the

9
00:00:30,470 --> 00:00:28,800
continental crust so these are

10
00:00:31,990 --> 00:00:30,480
microorganisms that live several

11
00:00:34,229 --> 00:00:32,000
kilometers deep

12
00:00:35,590 --> 00:00:34,239
in natural fractures within crystalline

13
00:00:37,510 --> 00:00:35,600

rock

14
00:00:38,950 --> 00:00:37,520
and we call these systems extreme

15
00:00:41,030 --> 00:00:38,960
environments due to the high

16
00:00:42,869 --> 00:00:41,040
temperatures and pressures as well as

17
00:00:46,549 --> 00:00:42,879
low nutrient availability in these

18
00:00:48,549 --> 00:00:46,559
systems and despite these conditions we

19
00:00:50,790 --> 00:00:48,559
still see that microbial communities are

20
00:00:52,790 --> 00:00:50,800
surviving for geological time scales

21
00:00:55,270 --> 00:00:52,800
within these environments

22
00:00:57,189 --> 00:00:55,280
so of course for astrobiologists this is

23
00:00:59,189 --> 00:00:57,199
an important question or important

24
00:01:00,869 --> 00:00:59,199
system to look at just because we're

25
00:01:02,709 --> 00:01:00,879
wondering is there a possibility that

26
00:01:05,350 --> 00:01:02,719
there's life in the subsurface of other

27
00:01:09,830 --> 00:01:05,360
planets or of moons and how could they

28
00:01:13,910 --> 00:01:12,070
so this diagram is a representation of

29
00:01:15,270 --> 00:01:13,920
the carbon cycle in the deep terrestrial

30
00:01:17,910 --> 00:01:15,280
subsurface

31
00:01:20,950 --> 00:01:17,920
so in yellow boxes we have the carbon

32
00:01:22,870 --> 00:01:20,960
pools and in the black boxes we have the

33
00:01:25,590 --> 00:01:22,880
organisms involved

34
00:01:27,510 --> 00:01:25,600
so the earth's surface and the shallow

35
00:01:34,149 --> 00:01:27,520
subsurface are ultimately dependent on

36
00:01:39,109 --> 00:01:36,469
so we have photosynthesis up here

37
00:01:41,109 --> 00:01:39,119
producing oxygen and organic carbon and

38
00:01:43,590 --> 00:01:41,119

this organic carbon is either buried or

39
00:01:45,590 --> 00:01:43,600
it's utilized by heterotrophic organisms

40
00:01:49,350 --> 00:01:45,600
such as sulfate reducing bacteria and

41
00:01:53,429 --> 00:01:51,350
as we go deeper in the subsurface this

42
00:01:56,069 --> 00:01:53,439
organic carbon may become unavailable

43
00:01:57,670 --> 00:01:56,079
for heterotrophs and organisms are going

44
00:02:00,069 --> 00:01:57,680
to have to rely on an alternative

45
00:02:02,590 --> 00:02:00,079
mechanism to fix carbon

46
00:02:05,270 --> 00:02:02,600
so one hypothesis is a hydrogen-driven

47
00:02:07,030 --> 00:02:05,280
chemolitho-autotrophic community

48
00:02:10,229 --> 00:02:07,040
and this is based on

49
00:02:12,949 --> 00:02:10,239
the concept that hydrogen is produced by

50
00:02:14,949 --> 00:02:12,959
abiotic processes such as outgassing

51
00:02:16,710 --> 00:02:14,959
water rock interaction and radiolytic

52
00:02:18,550 --> 00:02:16,720
decomposition of water

53
00:02:20,949 --> 00:02:18,560
and this hydrogen can be utilized by

54
00:02:22,869 --> 00:02:20,959
acetogens and methanogens to produce

55
00:02:25,110 --> 00:02:22,879
acetate and methane

56
00:02:28,309 --> 00:02:25,120
and acetoclastic methanogens can utilize

57
00:02:29,430 --> 00:02:28,319
this acetate and produce methane

58
00:02:31,190 --> 00:02:29,440
and

59
00:02:34,229 --> 00:02:31,200
all this methane that is produced can be

60
00:02:36,309 --> 00:02:34,239
utilized by methanotrophic bacteria

61
00:02:37,990 --> 00:02:36,319
which produce hydrogen and co2 as a

62
00:02:41,270 --> 00:02:38,000
result so

63
00:02:43,509 --> 00:02:41,280

evidently methane is an important uh

64
00:02:47,270 --> 00:02:43,519
important point in this in this

65
00:02:50,630 --> 00:02:48,869
so in this study we're using

66
00:02:52,630 --> 00:02:50,640
phospholipid fatty acids as

67
00:02:54,390 --> 00:02:52,640
biosignatures for viable microbial

68
00:02:57,030 --> 00:02:54,400
communities

69
00:02:59,030 --> 00:02:57,040
so phospholipids are a major component

70
00:03:01,030 --> 00:02:59,040
of bacterial and eukaryotic cell

71
00:03:03,270 --> 00:03:01,040
membranes and they're known to degrade

72
00:03:05,110 --> 00:03:03,280
rapidly upon cell death

73
00:03:07,670 --> 00:03:05,120
so as a result we can use these as

74
00:03:09,750 --> 00:03:07,680
indicators for microbial life that is

75
00:03:11,430 --> 00:03:09,760
actually alive

76
00:03:13,830 --> 00:03:11,440
secondly we can look at the

77
00:03:15,270 --> 00:03:13,840
concentrations of the plfa to estimate

78
00:03:16,550 --> 00:03:15,280
the cell densities within these

79
00:03:17,750 --> 00:03:16,560
environments

80
00:03:19,589 --> 00:03:17,760
and thirdly we can look at the

81
00:03:21,830 --> 00:03:19,599
composition of the plfas to get an idea

82
00:03:23,670 --> 00:03:21,840
of what kind of microbial communities or

83
00:03:27,270 --> 00:03:23,680
what kind of microorganisms are present

84
00:03:30,149 --> 00:03:28,149
so

85
00:03:32,229 --> 00:03:30,159
in addition to plfa analysis we've used

86
00:03:35,030 --> 00:03:32,239
two carbon isotope analyses and the

87
00:03:36,550 --> 00:03:35,040
first one is delta c13

88
00:03:38,390 --> 00:03:36,560

which we heard a little bit about

89
00:03:40,470 --> 00:03:38,400
yesterday

90
00:03:45,509 --> 00:03:40,480
and what we're interested in for this

91
00:03:47,589 --> 00:03:45,519
technique is uh c12 and c13 only not c14

92
00:03:49,830 --> 00:03:47,599
and to illustrate this concept i've

93
00:03:51,110 --> 00:03:49,840
included these

94
00:03:53,110 --> 00:03:51,120
these three

95
00:03:55,430 --> 00:03:53,120
carbon sources dissolved in organic

96
00:03:56,470 --> 00:03:55,440
carbon dissolved organic carbon and

97
00:03:58,470 --> 00:03:56,480
methane

98
00:04:00,309 --> 00:03:58,480
and autotrophy heterotrophy and

99
00:04:02,789 --> 00:04:00,319
methanotrophy are the processes by which

100
00:04:04,470 --> 00:04:02,799
microorganisms will uptake this carbon

101
00:04:06,949 --> 00:04:04,480
from these sources

102
00:04:09,030 --> 00:04:06,959
and they may use this carbon to produce

103
00:04:11,830 --> 00:04:09,040
plfa

104
00:04:13,750 --> 00:04:11,840
so the important point for delta c13

105
00:04:15,670 --> 00:04:13,760
analysis is that microorganisms

106
00:04:17,749 --> 00:04:15,680
preferentially use the lighter carbon

107
00:04:18,550 --> 00:04:17,759
isotope c12

108
00:04:20,150 --> 00:04:18,560
so

109
00:04:21,189 --> 00:04:20,160
if we have a

110
00:04:23,990 --> 00:04:21,199
ratio

111
00:04:25,590 --> 00:04:24,000
or a particular delta c13 value for the

112
00:04:28,070 --> 00:04:25,600
carbon source

113
00:04:29,510 --> 00:04:28,080

which is basically the ratio of c13 to

114
00:04:32,550 --> 00:04:29,520
c12

115
00:04:34,629 --> 00:04:32,560
if a microorganism uptakes that carbon

116
00:04:36,390 --> 00:04:34,639
it'll preferentially use c12 so that

117
00:04:38,550 --> 00:04:36,400
ratio will decrease and we'll see a more

118
00:04:40,469 --> 00:04:38,560
negative delta c13

119
00:04:42,710 --> 00:04:40,479
and then when they produce plfa you'll

120
00:04:44,870 --> 00:04:42,720
also see that fractionation so the plfa

121
00:04:48,070 --> 00:04:44,880
will be even more depleted

122
00:04:50,230 --> 00:04:48,080
and the extent of this fractionation

123
00:04:52,950 --> 00:04:50,240
depends on the metabolism so

124
00:04:54,710 --> 00:04:52,960
we can look at these delta c13 values to

125
00:04:57,270 --> 00:04:54,720
think about what kind of metabolisms are

126
00:05:00,150 --> 00:04:57,280
occurring in these systems

127
00:05:02,790 --> 00:05:00,160
the second carbon isotope analysis or

128
00:05:05,749 --> 00:05:02,800
technique that we use is radiocarbon

129
00:05:09,590 --> 00:05:05,759
and this is based on the idea that c14

130
00:05:12,390 --> 00:05:09,600
is radioactive and it decays over time

131
00:05:17,189 --> 00:05:15,189
in this case if we have a certain amount

132
00:05:19,110 --> 00:05:17,199
of c14

133
00:05:21,510 --> 00:05:19,120
in your carbon source

134
00:05:23,749 --> 00:05:21,520
we won't see that fractionation effect

135
00:05:24,950 --> 00:05:23,759
due to the equations that we're using uh

136
00:05:27,110 --> 00:05:24,960
for delta c

137
00:05:29,510 --> 00:05:27,120
delta c14

138
00:05:30,710 --> 00:05:29,520

so in this case if a microorganism is

139
00:05:32,390 --> 00:05:30,720
using

140
00:05:34,790 --> 00:05:32,400
one particular carbon source that has a

141
00:05:37,830 --> 00:05:34,800
specific delta 14c value we should see

142
00:05:40,070 --> 00:05:37,840
that same value in the microbial biomass

143
00:05:41,830 --> 00:05:40,080
and again in the plfa so we can look at

144
00:05:43,670 --> 00:05:41,840
the microbial carbon sources using this

145
00:05:44,469 --> 00:05:43,680
technique

146
00:05:46,230 --> 00:05:44,479
so

147
00:05:47,590 --> 00:05:46,240
sampling from the deep subsurface is

148
00:05:49,590 --> 00:05:47,600
difficult just because of the

149
00:05:51,189 --> 00:05:49,600
inaccessibility of these

150
00:05:53,830 --> 00:05:51,199
of these systems

151
00:05:55,749 --> 00:05:53,840
but luckily some of the deepest mines in

152
00:05:58,070 --> 00:05:55,759
the world are located in south africa

153
00:05:59,110 --> 00:05:58,080
and they provide us with access to these

154
00:06:01,990 --> 00:05:59,120
systems

155
00:06:03,110 --> 00:06:02,000
up to 3.5 kilometers depth

156
00:06:05,510 --> 00:06:03,120
so

157
00:06:07,510 --> 00:06:05,520
basically the exploratory boreholes that

158
00:06:09,510 --> 00:06:07,520
they drill into the walls of the tunnels

159
00:06:11,189 --> 00:06:09,520
can sometimes tap into reservoirs of

160
00:06:12,390 --> 00:06:11,199
water which may contain microbial

161
00:06:14,390 --> 00:06:12,400
communities

162
00:06:17,830 --> 00:06:14,400
and what we do is go down into these

163
00:06:20,710 --> 00:06:17,840

mines and filter this water and then

164
00:06:23,749 --> 00:06:20,720
do analyses such as plfa analysis or

165
00:06:26,309 --> 00:06:23,759
other people are doing like dna analysis

166
00:06:28,550 --> 00:06:26,319
just to gain insight into who's there

167
00:06:30,230 --> 00:06:28,560
so in this system or in this study we

168
00:06:32,309 --> 00:06:30,240
are looking at six samples from four

169
00:06:33,830 --> 00:06:32,319
different minds and these four minds are

170
00:06:36,070 --> 00:06:33,840
drifantene

171
00:06:37,909 --> 00:06:36,080
kluth and beatrix

172
00:06:40,150 --> 00:06:37,919
and the depths of these samples come

173
00:06:42,790 --> 00:06:40,160
from about one kilometer depth to about

174
00:06:45,270 --> 00:06:42,800
3.5

175
00:06:46,790 --> 00:06:45,280
so we looked at we extracted plfa from

176
00:06:49,990 --> 00:06:46,800
the six samples

177
00:06:52,629 --> 00:06:50,000
and used those concentrations of plfa to

178
00:06:54,790 --> 00:06:52,639
estimate cell densities within these

179
00:06:55,590 --> 00:06:54,800
within these environments

180
00:06:57,909 --> 00:06:55,600
so

181
00:07:00,230 --> 00:06:57,919
as you can see the cell densities are

182
00:07:02,150 --> 00:07:00,240
actually very low in all all across the

183
00:07:03,830 --> 00:07:02,160
six samples

184
00:07:05,670 --> 00:07:03,840
at less than 10 to the five cells per

185
00:07:08,550 --> 00:07:05,680
milliliter of water

186
00:07:10,710 --> 00:07:08,560
and this is consistent with direct cell

187
00:07:12,790 --> 00:07:10,720
counts via microscopy as well as

188
00:07:16,870 --> 00:07:12,800

previous investigations of other

189
00:07:20,870 --> 00:07:18,390
in the case of kluth this is an

190
00:07:22,629 --> 00:07:20,880
extremely low cell density

191
00:07:24,469 --> 00:07:22,639
it's actually estimated at about 20

192
00:07:25,670 --> 00:07:24,479
cells per mil

193
00:07:27,350 --> 00:07:25,680
so for those of you who are

194
00:07:29,670 --> 00:07:27,360
microbiologists you'll probably

195
00:07:33,110 --> 00:07:29,680
appreciate that this is extremely low

196
00:07:34,230 --> 00:07:33,120
and slightly or very interesting

197
00:07:36,629 --> 00:07:34,240
because

198
00:07:38,070 --> 00:07:36,639
this raises the question for us as to

199
00:07:39,830 --> 00:07:38,080
whether there's actually anything living

200
00:07:43,990 --> 00:07:39,840
there perhaps this is actually just

201
00:07:49,270 --> 00:07:46,870
so we also looked at the

202
00:07:51,670 --> 00:07:49,280
composition of the plfa to identify

203
00:07:54,070 --> 00:07:51,680
different microbial groups and this uh

204
00:07:55,430 --> 00:07:54,080
diagram here just represents

205
00:07:57,430 --> 00:07:55,440
the differences between the different

206
00:07:59,589 --> 00:07:57,440
systems so what we see when we look at

207
00:08:01,510 --> 00:07:59,599
this is that they do the composition of

208
00:08:02,710 --> 00:08:01,520
the communities varies

209
00:08:05,510 --> 00:08:02,720
and we see

210
00:08:08,309 --> 00:08:05,520
some similar some similarities between

211
00:08:09,909 --> 00:08:08,319
the two beatrix samples uh drifontaine

212
00:08:12,790 --> 00:08:09,919
contained evidence for gram-positive

213
00:08:15,589 --> 00:08:12,800

bacteria and sulfate reducers tautona 1

214
00:08:17,589 --> 00:08:15,599
and 2 and beatrix 1 and 2

215
00:08:19,510 --> 00:08:17,599
contain these cyclic

216
00:08:21,270 --> 00:08:19,520
plfa which are

217
00:08:22,869 --> 00:08:21,280
indicators for

218
00:08:25,830 --> 00:08:22,879
microbial responses to environmental

219
00:08:26,629 --> 00:08:25,840
stressors such as nutrient

220
00:08:29,909 --> 00:08:26,639
but

221
00:08:30,950 --> 00:08:29,919
overall what we find from this is that

222
00:08:32,630 --> 00:08:30,960
we're seeing differences in the

223
00:08:35,509 --> 00:08:32,640
microbial communities so we're probably

224
00:08:37,750 --> 00:08:35,519
going to see differences in metabolisms

225
00:08:39,509 --> 00:08:37,760
and this is in fact what we see

226
00:08:41,670 --> 00:08:39,519
we see

227
00:08:45,110 --> 00:08:41,680
here we're looking at the delta c13

228
00:08:47,590 --> 00:08:45,120
values of plfa which are

229
00:08:49,910 --> 00:08:47,600
indicated

230
00:08:51,990 --> 00:08:49,920
by the orange boxes and then we also

231
00:08:53,670 --> 00:08:52,000
have three potential carbon sources

232
00:08:57,110 --> 00:08:53,680
dissolved in organic carbon dissolved

233
00:08:58,710 --> 00:08:57,120
organic carbon and methane

234
00:09:01,430 --> 00:08:58,720
and

235
00:09:02,870 --> 00:09:01,440
for drifontaine we saw very depleted

236
00:09:05,670 --> 00:09:02,880
plfa

237
00:09:07,910 --> 00:09:05,680
and the negative offset from methane is

238
00:09:09,990 --> 00:09:07,920

indicative of some utilization of

239
00:09:12,070 --> 00:09:10,000
methane as a carbon source so

240
00:09:14,150 --> 00:09:12,080
methanotrophy

241
00:09:15,509 --> 00:09:14,160
for tautona one and tautomeno two and

242
00:09:18,790 --> 00:09:15,519
beatrix

243
00:09:21,910 --> 00:09:18,800
uh the negative offset from the

244
00:09:23,190 --> 00:09:21,920
dic to plfa is indicative of autotrophic

245
00:09:27,430 --> 00:09:23,200
communities

246
00:09:28,790 --> 00:09:27,440
and then for beatrix we actually see we

247
00:09:31,750 --> 00:09:28,800
we think that there's a combination of

248
00:09:33,509 --> 00:09:31,760
methanotropic activity as well as

249
00:09:35,190 --> 00:09:33,519
autotrophy

250
00:09:37,750 --> 00:09:35,200
in terms of cliff this is the sample

251
00:09:40,230 --> 00:09:37,760
with the very low cell density um we

252
00:09:41,509 --> 00:09:40,240
didn't have enough plfa for delta c13

253
00:09:44,389 --> 00:09:41,519
analysis

254
00:09:46,949 --> 00:09:44,399
but these values for dic and methane are

255
00:09:49,670 --> 00:09:46,959
consistent with a lack of methanogenesis

256
00:09:51,430 --> 00:09:49,680
and abiotic methane so that's

257
00:09:55,910 --> 00:09:51,440
interesting in terms of

258
00:10:00,710 --> 00:09:58,790
and we also used radiocarbon analysis

259
00:10:03,350 --> 00:10:00,720
delta c14

260
00:10:05,990 --> 00:10:03,360
and to confirm the carbon sources so

261
00:10:07,269 --> 00:10:06,000
for dry fontaine the plfa were slightly

262
00:10:09,509 --> 00:10:07,279
more enriched than the dissolved

263
00:10:11,829 --> 00:10:09,519

inorganic carbon and methane

264
00:10:13,750 --> 00:10:11,839
so it looks like there is some influence

265
00:10:15,430 --> 00:10:13,760
from these two carbon pools but perhaps

266
00:10:17,030 --> 00:10:15,440
there's slightly younger carbon coming

267
00:10:19,670 --> 00:10:17,040
in as well

268
00:10:22,870 --> 00:10:19,680
for tautona 1 it's consistent with what

269
00:10:25,269 --> 00:10:22,880
we saw with delta c13 they're utilizing

270
00:10:26,630 --> 00:10:25,279
dic as a carbon source so autotrophic

271
00:10:27,829 --> 00:10:26,640
processes

272
00:10:31,350 --> 00:10:27,839
and

273
00:10:34,069 --> 00:10:31,360
for tautona 2 same same thing um

274
00:10:36,069 --> 00:10:34,079
consistent with autotrophic processes

275
00:10:38,389 --> 00:10:36,079
and beatrix again it looks like there's

276
00:10:40,949 --> 00:10:38,399
they're utilizing dic and methane so

277
00:10:42,630 --> 00:10:40,959
autotrophy and methanotrophy and as

278
00:10:45,350 --> 00:10:42,640
you'll notice we haven't we don't have

279
00:10:47,350 --> 00:10:45,360
measurements for doc here so organic

280
00:10:49,430 --> 00:10:47,360
carbon just because in these systems

281
00:10:51,829 --> 00:10:49,440
organic carbon is usually very low and

282
00:10:53,269 --> 00:10:51,839
so it's in all these cases it was very

283
00:10:55,110 --> 00:10:53,279
difficult to measure

284
00:10:57,509 --> 00:10:55,120
radiocarbon

285
00:10:59,030 --> 00:10:57,519
so we have to keep that in mind

286
00:11:01,430 --> 00:10:59,040
so basically

287
00:11:04,550 --> 00:11:01,440
my overall conclusions from this is that

288
00:11:06,310 --> 00:11:04,560

possible fatty acid analysis is a useful

289
00:11:07,670 --> 00:11:06,320
tool for looking at viable microbial

290
00:11:08,870 --> 00:11:07,680
communities in the deep terrestrial

291
00:11:11,190 --> 00:11:08,880
subsurface

292
00:11:13,670 --> 00:11:11,200
carbon isotopes can provide insight into

293
00:11:16,150 --> 00:11:13,680
the microbial metabolisms that are

294
00:11:16,949 --> 00:11:16,160
occurring in these systems

295
00:11:19,910 --> 00:11:16,959
and

296
00:11:23,269 --> 00:11:19,920
in the case of our samples

297
00:11:25,509 --> 00:11:23,279
we observed plfa in all of our samples

298
00:11:27,990 --> 00:11:25,519
extremely low cell densities and some of

299
00:11:29,350 --> 00:11:28,000
them particularly in the one sample

300
00:11:30,790 --> 00:11:29,360
clues

301
00:11:32,389 --> 00:11:30,800
and we also observed a range of

302
00:11:35,269 --> 00:11:32,399
microbial metabolisms including

303
00:11:37,190 --> 00:11:35,279
methanotrophy and autotrophy so the

304
00:11:39,670 --> 00:11:37,200
presence of these or the observation of

305
00:11:41,350 --> 00:11:39,680
these two metabolisms is consistent with

306
00:11:43,590 --> 00:11:41,360
perhaps the chemolithoautotrophic

307
00:11:45,829 --> 00:11:43,600
community

308
00:11:47,269 --> 00:11:45,839
so again as astrobiologists i'm just

309
00:11:49,030 --> 00:11:47,279
highlighting the implications of this

310
00:11:50,790 --> 00:11:49,040
study

311
00:11:53,269 --> 00:11:50,800
worth wondering is there life on the

312
00:11:57,269 --> 00:11:53,279
subsurface of other planets and moons

313
00:11:59,350 --> 00:11:57,279

so could in if we had a system um or a

314
00:12:01,750 --> 00:11:59,360
planet that you know the the surface of

315
00:12:04,150 --> 00:12:01,760
the planet or moon was inhospitable to

316
00:12:06,870 --> 00:12:04,160
life could there be life surviving

317
00:12:08,629 --> 00:12:06,880
independent of the photosphere

318
00:12:11,350 --> 00:12:08,639
and could those microbial communities

319
00:12:13,269 --> 00:12:11,360
survive over geological time skills

320
00:12:14,949 --> 00:12:13,279
and so this point is

321
00:12:17,030 --> 00:12:14,959
very interesting for some of you may

322
00:12:18,710 --> 00:12:17,040
have heard about a month ago there was a

323
00:12:21,670 --> 00:12:18,720
paper in

324
00:12:23,430 --> 00:12:21,680
nature by holland at all and there they

325
00:12:26,790 --> 00:12:23,440
actually are looking in a different mine

326
00:12:29,190 --> 00:12:26,800
site in canada and they have found

327
00:12:30,150 --> 00:12:29,200
water that is about 2.7 billion years

328
00:12:31,030 --> 00:12:30,160
old

329
00:12:33,110 --> 00:12:31,040
and

330
00:12:34,470 --> 00:12:33,120
in our systems we are seeing very old

331
00:12:37,190 --> 00:12:34,480
water like

332
00:12:40,150 --> 00:12:37,200
approximately 20 million years old but

333
00:12:43,110 --> 00:12:40,160
to see microbial communities living in a

334
00:12:47,030 --> 00:12:43,120
system that is 2.7 billion years old is

335
00:12:48,310 --> 00:12:47,040
pretty incredible so um just a note for

336
00:12:50,150 --> 00:12:48,320
you guys to

337
00:12:52,230 --> 00:12:50,160
look at that and then also just as

338
00:12:55,190 --> 00:12:52,240

another point survival through the late

339
00:12:57,590 --> 00:12:55,200
heavy bombardment if

340
00:13:00,230 --> 00:12:57,600
this is kind of an origins question but

341
00:13:01,590 --> 00:13:00,240
in the early earth maybe the surface of

342
00:13:04,389 --> 00:13:01,600
the earth could have been sterilized by

343
00:13:06,470 --> 00:13:04,399
that 3.8 billion years ago there's the

344
00:13:08,550 --> 00:13:06,480
meteorite impacts and

345
00:13:10,629 --> 00:13:08,560
um could life have survived through that

346
00:13:11,750 --> 00:13:10,639
by living in the subsurface

347
00:13:13,670 --> 00:13:11,760
so overall there's lots of

348
00:13:15,910 --> 00:13:13,680
astrobiological implications

349
00:13:17,670 --> 00:13:15,920
and i just want to thank the south

350
00:13:19,190 --> 00:13:17,680
africa gold mines for providing us with

351
00:13:21,030 --> 00:13:19,200
access to these systems because

352
00:13:23,670 --> 00:13:21,040
otherwise we would never be able to look

353
00:13:25,509 --> 00:13:23,680
at them and also my collaborators tell

354
00:13:27,110 --> 00:13:25,519
us onstop barbara sherwood lawler

355
00:13:29,910 --> 00:13:27,120
kenneth wilkie

356
00:13:31,509 --> 00:13:29,920
eric womack and eric sakowski and my lab

357
00:13:46,710 --> 00:13:31,519
group including my supervisor greg

358
00:13:50,629 --> 00:13:48,230
i'm particularly interested where you're

359
00:13:52,230 --> 00:13:50,639
looking at the carbon-14 and the site

360
00:13:54,629 --> 00:13:52,240
where you had the highest

361
00:13:57,590 --> 00:13:54,639
percentage of uh carbon-14 incorporated

362
00:13:58,790 --> 00:13:57,600
in your organic material yeah

363
00:14:00,949 --> 00:13:58,800

the fact that yeah it looks like your

364
00:14:02,470 --> 00:14:00,959
metabolisms were doing doc the fact that

365
00:14:03,750 --> 00:14:02,480
there's any carbon-14 at all do you

366
00:14:05,590 --> 00:14:03,760
think that you're still getting just

367
00:14:07,350 --> 00:14:05,600
telegraphed stuff from the surface i

368
00:14:09,670 --> 00:14:07,360
mean if it's been relic for a million

369
00:14:11,189 --> 00:14:09,680
years there shouldn't be any carbon 14

370
00:14:13,509 --> 00:14:11,199
really exactly

371
00:14:15,509 --> 00:14:13,519
um it depends on the system so i haven't

372
00:14:17,350 --> 00:14:15,519
included exactly the ages of these

373
00:14:20,710 --> 00:14:17,360
systems and i can't remember them all

374
00:14:23,030 --> 00:14:20,720
part um you know by heart but i um

375
00:14:24,550 --> 00:14:23,040
yes you know we have to think about

376
00:14:26,470 --> 00:14:24,560
um

377
00:14:27,269 --> 00:14:26,480
where is this organic carbon coming from

378
00:14:29,590 --> 00:14:27,279
and

379
00:14:32,389 --> 00:14:29,600
um in some cases we did measure a

380
00:14:35,910 --> 00:14:32,399
dissolved or organic carbon

381
00:14:38,150 --> 00:14:35,920
radiocarbon measurement and

382
00:14:40,550 --> 00:14:38,160
it's actually very difficult to do

383
00:14:42,230 --> 00:14:40,560
because we use these resin columns

384
00:14:44,790 --> 00:14:42,240
i actually don't do it personally but

385
00:14:46,790 --> 00:14:44,800
our collaborators do and um you know

386
00:14:49,269 --> 00:14:46,800
sometimes we have to think about whether

387
00:14:51,509 --> 00:14:49,279
we're introducing young organic carbon

388
00:14:53,269 --> 00:14:51,519

to that pool so

389
00:14:55,110 --> 00:14:53,279
um

390
00:14:56,790 --> 00:14:55,120
yeah so

391
00:14:57,990 --> 00:14:56,800
i don't know i

392
00:14:59,750 --> 00:14:58,000
yeah it's something to think about

393
00:15:01,110 --> 00:14:59,760
whether like what how much influence

394
00:15:03,110 --> 00:15:01,120
there is from the surface which is

395
00:15:04,710 --> 00:15:03,120
exactly what what we're looking at is

396
00:15:10,790 --> 00:15:04,720
can you know are they completely

397
00:15:15,030 --> 00:15:12,629
i'm just wondering whether either you or

398
00:15:16,389 --> 00:15:15,040
any of your collaborators uh have done

399
00:15:18,069 --> 00:15:16,399
or are thinking about doing any

400
00:15:19,670 --> 00:15:18,079
culture-based work with this system

401
00:15:21,189 --> 00:15:19,680
trying to actually grow up anything

402
00:15:23,750 --> 00:15:21,199
that's down there

403
00:15:26,470 --> 00:15:23,760
i you know we have such a like such a

404
00:15:28,389 --> 00:15:26,480
huge group of collaborators i'm doing

405
00:15:30,310 --> 00:15:28,399
everything you know dna analysis i i

406
00:15:33,670 --> 00:15:30,320
believe we do have some doing culture

407
00:15:49,430 --> 00:15:33,680
work um but i'm not entirely sure

408
00:15:55,910 --> 00:15:52,710
so with respect to the methanol trophy

409
00:15:59,269 --> 00:15:55,920
is your system totally loxic or

410
00:16:01,350 --> 00:15:59,279
do you get can the plfa analysis hint uh

411
00:16:04,069 --> 00:16:01,360
towards which type of methanol trophy

412
00:16:05,110 --> 00:16:04,079
this uh these uh communities are

413
00:16:06,870 --> 00:16:05,120

undergoing

414
00:16:08,150 --> 00:16:06,880
yeah so

415
00:16:11,590 --> 00:16:08,160
that's that's a good question because

416
00:16:13,430 --> 00:16:11,600
methanotrophy is typically a um aerobic

417
00:16:16,710 --> 00:16:13,440
process but then you have the anaerobic

418
00:16:19,030 --> 00:16:16,720
process of methanogen methanotropes and

419
00:16:19,829 --> 00:16:19,040
the animoxon right

420
00:16:22,470 --> 00:16:19,839
so

421
00:16:24,509 --> 00:16:22,480
um with which is a kind of a

422
00:16:27,829 --> 00:16:24,519
consortium of uh

423
00:16:29,269 --> 00:16:27,839
methanotrophic bacteria and um sulfate

424
00:16:31,509 --> 00:16:29,279
reducers i believe

425
00:16:32,389 --> 00:16:31,519
archaea but yeah archaea

426
00:16:33,990 --> 00:16:32,399
um

427
00:16:36,230 --> 00:16:34,000
so yeah it's an interesting question

428
00:16:37,590 --> 00:16:36,240
because we actually for that one sample

429
00:16:40,389 --> 00:16:37,600
that was always on the left of the

430
00:16:41,670 --> 00:16:40,399
graphs where we saw methanotrophy or

431
00:16:43,350 --> 00:16:41,680
you know it

432
00:16:45,590 --> 00:16:43,360
the carbon isotopes definitely say

433
00:16:47,990 --> 00:16:45,600
methanotrophy um we're not actually

434
00:16:50,470 --> 00:16:48,000
seeing the biomarkers for methanotrophy

435
00:16:52,470 --> 00:16:50,480
so there's a couple plfa biomarkers that

436
00:16:53,509 --> 00:16:52,480
are indicative of methanotrops um

437
00:16:55,990 --> 00:16:53,519
aerobic

438
00:16:57,430 --> 00:16:56,000

methanotropes so we're not seeing those

439
00:16:59,670 --> 00:16:57,440
so that's what i'm starting i'm trying

440
00:17:01,829 --> 00:16:59,680
to think about is like you know how what

441
00:17:04,309 --> 00:17:01,839
is actually occurring here because or

442
00:17:06,309 --> 00:17:04,319
you know maybe not all methanotrops have

443
00:17:07,350 --> 00:17:06,319
those biomarkers so

444
00:17:09,029 --> 00:17:07,360
um

445
00:17:10,470 --> 00:17:09,039
but yeah i mean if i could see those

446
00:17:13,669 --> 00:17:10,480
biomarkers then i would know for sure

447
00:17:16,069 --> 00:17:13,679
that it is aerobic um but we do we do

448
00:17:18,069 --> 00:17:16,079
have oxygen in some of these systems so

449
00:17:20,150 --> 00:17:18,079
yeah do you have any uh dead on the

450
00:17:22,230 --> 00:17:20,160
nitrate present because that's a

451
00:17:25,110 --> 00:17:22,240
alternative pathway for bacterial

452
00:17:27,510 --> 00:17:25,120
methanotrophy under anoxic conditions uh

453
00:17:29,270 --> 00:17:27,520
you know what actually i can't really

454
00:17:33,270 --> 00:17:29,280
think offhand of what we have yeah for

455
00:17:37,750 --> 00:17:36,390
last question i think

456
00:17:39,430 --> 00:17:37,760
i'm just out of curiosity how do you

457
00:17:43,430 --> 00:17:39,440
date water

458
00:17:45,190 --> 00:17:43,440
find something that's 2.7

459
00:17:47,029 --> 00:17:45,200
yeah just out of somebody might know

460
00:17:49,990 --> 00:17:47,039
this better than me but i believe it's

461
00:17:52,310 --> 00:17:50,000
i'm having to do with um oxygen isotopes

462
00:17:54,789 --> 00:17:52,320
and hydrogen isotopes yeah okay i see

463
00:17:57,510 --> 00:17:54,799

nodding heads

464
00:17:59,270 --> 00:17:57,520
yeah yeah