
AbSciCon
2019

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

2
00:00:12,340 --> 00:00:09,060
[Applause]

3
00:00:14,560 --> 00:00:12,350
all right thank you all for thank you to

4
00:00:16,390 --> 00:00:14,570
the convenience Guinea's for having me

5
00:00:18,429 --> 00:00:16,400
in this session and for all of you for

6
00:00:20,380 --> 00:00:18,439
sticking doll of the very end pretty

7
00:00:23,080 --> 00:00:20,390
much the second last talk is pretty much

8
00:00:25,839 --> 00:00:23,090
the end I'm going to switch gears and

9
00:00:27,639 --> 00:00:25,849
move to laboratory investigations from

10
00:00:29,460 --> 00:00:27,649
from theoretical conversations in the

11
00:00:31,389 --> 00:00:29,470
previous talk and talk about

12
00:00:33,490 --> 00:00:31,399
physiological mechanisms and mineral

13
00:00:37,690 --> 00:00:33,500

transformations of hyperthermophilic ion

14
00:00:39,819 --> 00:00:37,700
reduction so this is probably a gross

15
00:00:42,220 --> 00:00:39,829
oversimplification but I want to remind

16
00:00:44,709 --> 00:00:42,230
and reiterate that on earth we know that

17
00:00:46,840 --> 00:00:44,719
biology greatly influences geology and

18
00:00:49,419 --> 00:00:46,850
it's this coevolution of life and Earth

19
00:00:51,579 --> 00:00:49,429
that yields organic geochemical and

20
00:00:53,799 --> 00:00:51,589
mineral clues to trace and describe some

21
00:00:55,750 --> 00:00:53,809
of the earliest life on our planet now

22
00:00:58,630 --> 00:00:55,760
among the mineral clues that we turn to

23
00:01:00,430 --> 00:00:58,640
our iron minerals such as iron oxides

24
00:01:02,069 --> 00:01:00,440
that we know today have been central to

25
00:01:05,439 --> 00:01:02,079
some of the earliest biological

26
00:01:08,260 --> 00:01:05,449
metabolisms yet when we look at the rock

27
00:01:10,360 --> 00:01:08,270
record from a mineral perspective we

28
00:01:13,240 --> 00:01:10,370
don't know if we can discern a truly

29
00:01:14,920 --> 00:01:13,250
microvilli altered mineral so one

30
00:01:17,770 --> 00:01:14,930
approach to doing this would be perhaps

31
00:01:20,650 --> 00:01:17,780
to examine one specific micro mineral

32
00:01:22,930 --> 00:01:20,660
process to really get at identifying its

33
00:01:26,410 --> 00:01:22,940
mineral signatures and the mechanisms by

34
00:01:28,360 --> 00:01:26,420
which they form so I'm gonna make the

35
00:01:30,610 --> 00:01:28,370
argument that we can explore and better

36
00:01:33,460 --> 00:01:30,620
understand a micro mineral process such

37
00:01:36,730 --> 00:01:33,470
as hyperthermophilic ion reduction to do

38
00:01:38,530 --> 00:01:36,740

this now a hyperthermophiles just to

39
00:01:41,050 --> 00:01:38,540
revisit this fer of people in this

40
00:01:43,210 --> 00:01:41,060
audience who may not be a microbiologist

41
00:01:45,310 --> 00:01:43,220
a hypothermia file is an organism that

42
00:01:47,950 --> 00:01:45,320
grows optimally above 80 degrees Celsius

43
00:01:49,990 --> 00:01:47,960
and an iron reducer is an organism that

44
00:01:51,400 --> 00:01:50,000
couples the oxidation of organics or

45
00:01:54,430 --> 00:01:51,410
hydrogen with the extra cellular

46
00:01:56,140 --> 00:01:54,440
reduction of an iron oxide source to

47
00:01:58,360 --> 00:01:56,150
gain energy now this type of microbial

48
00:01:59,980 --> 00:01:58,370
metabolism occurs widely in in

49
00:02:02,500 --> 00:01:59,990
terrestrial hot springs in deep sea

50
00:02:04,600 --> 00:02:02,510
hydrothermal vents yet our understanding

51
00:02:10,570 --> 00:02:04,610
of its physiology as well as mineral

52
00:02:12,460 --> 00:02:10,580
transformations is extremely limited so

53
00:02:14,350 --> 00:02:12,470
we're actually probing and trying to

54
00:02:16,089 --> 00:02:14,360
understand this process a little closely

55
00:02:18,099 --> 00:02:16,099
using a model system a model

56
00:02:20,800 --> 00:02:18,109
crenarchaeota called podrick pardek Tim

57
00:02:22,210 --> 00:02:20,810
Delaney a type strain su o6

58
00:02:24,040 --> 00:02:22,220
now I want to highlight a few key

59
00:02:26,380 --> 00:02:24,050
characteristics about this organism

60
00:02:28,930 --> 00:02:26,390
before going any further so by reading

61
00:02:30,400 --> 00:02:28,940
Tim Delaney I is a isolate that was

62
00:02:32,980 --> 00:02:30,410
taken from an actively venting

63
00:02:36,040 --> 00:02:32,990

hydrothermal chimney and that grows

64
00:02:38,710 --> 00:02:36,050
optimally at 90 degrees Celsius and it's

65
00:02:40,479 --> 00:02:38,720
hydrogen atrophic and when it comes to

66
00:02:43,240 --> 00:02:40,489
electron acceptors it can only really

67
00:02:45,760 --> 00:02:43,250
use an insoluble iron oxide such as

68
00:02:48,520 --> 00:02:45,770
Farah hydride and nitrate but it is

69
00:02:51,070 --> 00:02:48,530
unable to use any soluble iron such as

70
00:02:53,320 --> 00:02:51,080
ferric citrate or any macro particulate

71
00:02:56,949 --> 00:02:53,330
crystalline oxides such as birth I'd

72
00:03:00,070 --> 00:02:56,959
hematite or magnetite now when it comes

73
00:03:02,199 --> 00:03:00,080
to looking at its genome we find that

74
00:03:04,630 --> 00:03:02,209
its genome encodes for these 17

75
00:03:05,949 --> 00:03:04,640
predicted C type cytochromes and many of

76
00:03:08,800 --> 00:03:05,959
these C type cytochromes are actually

77
00:03:11,860 --> 00:03:08,810
Multi heme proteins which we know from

78
00:03:13,990 --> 00:03:11,870
model mesophilic bacteria are are

79
00:03:18,460 --> 00:03:14,000
essential for extracellular electron

80
00:03:20,979 --> 00:03:18,470
transfer so we started off by asking

81
00:03:22,540 --> 00:03:20,989
that given this organism only given that

82
00:03:26,050 --> 00:03:22,550
this organism only grows on these

83
00:03:27,850 --> 00:03:26,060
insoluble iron oxides but not on any

84
00:03:30,789 --> 00:03:27,860
soluble iron does it use some of these

85
00:03:32,680 --> 00:03:30,799
other iron mineral phases and to really

86
00:03:34,680 --> 00:03:32,690
get at this question we decided to

87
00:03:37,780 --> 00:03:34,690
synthesize a range of nano phase

88
00:03:39,789 --> 00:03:37,790

minerals these several of these

89
00:03:42,850 --> 00:03:39,799
different types of iron oxides to test

90
00:03:45,069 --> 00:03:42,860
for growth and we found overall that the

91
00:03:46,990 --> 00:03:45,079
organism grows on a wide range of these

92
00:03:50,560 --> 00:03:47,000
minerals when they're presented as these

93
00:03:52,090 --> 00:03:50,570
nano particulate mineral phases I'll be

94
00:03:55,479 --> 00:03:52,100
to varying degrees depending on the

95
00:03:57,640 --> 00:03:55,489
oxide it grew to the highest cell

96
00:04:00,610 --> 00:03:57,650
concentration at the fastest growth rate

97
00:04:03,400 --> 00:04:00,620
producing the most Fe to using Farah

98
00:04:05,770 --> 00:04:03,410
hydride it grew to moderate cell

99
00:04:08,140 --> 00:04:05,780
concentrations growth rates and Fe to

100
00:04:10,680 --> 00:04:08,150
production using AK again a deliberate

101
00:04:14,020 --> 00:04:10,690
across I'd shown in green and orange and

102
00:04:16,300 --> 00:04:14,030
to the lowest cell concentrations growth

103
00:04:17,949 --> 00:04:16,310
rates and Fe to production using

104
00:04:20,710 --> 00:04:17,959
goethite and hematite now these results

105
00:04:22,529 --> 00:04:20,720
are not unsurprising given the expected

106
00:04:26,140 --> 00:04:22,539
crystallinity and thermodynamic

107
00:04:29,260 --> 00:04:26,150
stability of these phases but what is a

108
00:04:31,390 --> 00:04:29,270
key finding here is that the organism

109
00:04:33,070 --> 00:04:31,400
can use this wide range of minerals when

110
00:04:36,820 --> 00:04:33,080
we think about mineral parameters such

111
00:04:41,480 --> 00:04:39,140
now next we wanted to know given that

112
00:04:43,969 --> 00:04:41,490
this organism can use this wide range of

113
00:04:45,920 --> 00:04:43,979

mineral phases does it form mineral

114
00:04:48,499 --> 00:04:45,930
different mineral end products as a

115
00:04:51,529 --> 00:04:48,509
result of reduction and to really get at

116
00:04:53,659 --> 00:04:51,539
this question we do try to examine the

117
00:04:56,420 --> 00:04:53,669
mineral end products using a range of

118
00:04:58,460 --> 00:04:56,430
bulk and reflectance spectroscopy sa-2

119
00:05:00,740 --> 00:04:58,470
of which I will primarily be focusing on

120
00:05:02,210 --> 00:05:00,750
today to show you results this

121
00:05:04,100 --> 00:05:02,220
mid-infrared attenuated total

122
00:05:07,309 --> 00:05:04,110
reflectance and mossbauer spectroscopy

123
00:05:09,740 --> 00:05:07,319
x' in addition you will notice that many

124
00:05:12,589 --> 00:05:09,750
of these blots have a range of

125
00:05:14,330 --> 00:05:12,599
conditions and in spectra and the reason

126
00:05:15,980 --> 00:05:14,340
why this is is because we're looking at

127
00:05:18,649 --> 00:05:15,990
biogenic mineral transformations and

128
00:05:21,409 --> 00:05:18,659
comparing them to a suite of a biogenic

129
00:05:23,510 --> 00:05:21,419
or abiotic mineral transformations that

130
00:05:24,860 --> 00:05:23,520
may be plausible accounting for any

131
00:05:27,980 --> 00:05:24,870
transformations that may result from

132
00:05:31,339 --> 00:05:27,990
heat non growing cells or the growth

133
00:05:33,020 --> 00:05:31,349
medium itself what we find over all is

134
00:05:34,700 --> 00:05:33,030
that when Farrah hydrate transformations

135
00:05:38,140 --> 00:05:34,710
are considered that the organism

136
00:05:40,909 --> 00:05:38,150
primarily makes magnetite which is seen

137
00:05:44,779 --> 00:05:40,919
with the two prominent absorptions here

138
00:05:46,580 --> 00:05:44,789

for for the mineral phase and in the

139
00:05:48,290 --> 00:05:46,590
attenuated total reflectance and in the

140
00:05:50,059 --> 00:05:48,300
moss power as well we see the magnetite

141
00:05:51,980 --> 00:05:50,069
but in addition to the magnetite we also

142
00:05:53,629 --> 00:05:51,990
see minor amounts of ferrous phosphate

143
00:05:57,740 --> 00:05:53,639
and ferrous carbonate form relative to

144
00:05:59,240 --> 00:05:57,750
abiotic controls with lipid across side

145
00:06:00,980 --> 00:05:59,250
instead of magnetite we see the

146
00:06:04,369 --> 00:06:00,990
formation primarily of a ferrous

147
00:06:05,749 --> 00:06:04,379
carbonate phase such a siddha right in

148
00:06:08,269 --> 00:06:05,759
the attenuated total reflectance

149
00:06:10,580 --> 00:06:08,279
spectroscopy and in the Moskva we see

150
00:06:12,050 --> 00:06:10,590
that same phase but also in addition to

151
00:06:15,529 --> 00:06:12,060
that phase we see minor amounts of

152
00:06:18,769 --> 00:06:15,539
ferrous phosphate forming with AK again

153
00:06:21,409 --> 00:06:18,779
eh we see minor amounts of a ferrous

154
00:06:23,689 --> 00:06:21,419
phosphate phase as well as magnetite

155
00:06:28,850 --> 00:06:23,699
minor amount of magnetite form relative

156
00:06:30,170 --> 00:06:28,860
to the end to the abiotic controls now

157
00:06:32,930 --> 00:06:30,180
when we put together there is also

158
00:06:34,999 --> 00:06:32,940
showed you with regards to the rates of

159
00:06:37,490 --> 00:06:35,009
reduction and the spectral

160
00:06:39,439 --> 00:06:37,500
characteristics together we find that

161
00:06:42,469 --> 00:06:39,449
the minerals that form are really

162
00:06:45,260 --> 00:06:42,479
affected by the type of oxide that we we

163
00:06:47,029 --> 00:06:45,270

start and we think about growing these

164
00:06:47,750 --> 00:06:47,039
organisms with as well as the FE two

165
00:06:50,180 --> 00:06:47,760
flux

166
00:06:51,980 --> 00:06:50,190
now with Farah hydride we find which

167
00:06:54,740 --> 00:06:51,990
shows this fast rate of reduction in

168
00:06:57,130 --> 00:06:54,750
high Fe to accumulation magnetite

169
00:06:59,840 --> 00:06:57,140
nucleation and crystal growth is favored

170
00:07:01,310 --> 00:06:59,850
whereas and also in addition to that we

171
00:07:04,460 --> 00:07:01,320
see minor amounts of ferrous phosphate

172
00:07:06,530 --> 00:07:04,470
in carbonate forming with a lipid agro

173
00:07:09,200 --> 00:07:06,540
side which shows slow rates of reduction

174
00:07:12,200 --> 00:07:09,210
and low fe2 accumulation we see Sid

175
00:07:14,150 --> 00:07:12,210
right and ferrous phosphate forming with

176
00:07:16,910 --> 00:07:14,160
AK again yet which shows fast rates of

177
00:07:18,650 --> 00:07:16,920
reduction but significantly lower if we

178
00:07:21,050 --> 00:07:18,660
do accumulation relative to Farah

179
00:07:23,270 --> 00:07:21,060
hydride we see that minor amounts of

180
00:07:26,810 --> 00:07:23,280
magnetite and Affairs phosphate vivvy

181
00:07:28,040 --> 00:07:26,820
night can accumulate so context here can

182
00:07:29,510 --> 00:07:28,050
really make a difference in thinking

183
00:07:32,360 --> 00:07:29,520
about the different types of mineral

184
00:07:34,280 --> 00:07:32,370
phases that can form so from a

185
00:07:37,670 --> 00:07:34,290
physiological perspective we wanted to

186
00:07:39,860 --> 00:07:37,680
further probe and understand does this

187
00:07:42,380 --> 00:07:39,870
organism require cell mineral contact

188
00:07:44,270 --> 00:07:42,390

for reduction and to do this we really

189
00:07:48,410 --> 00:07:44,280
perform these barrier experiments that

190
00:07:49,880 --> 00:07:48,420
you that grew this organism with the

191
00:07:52,040 --> 00:07:49,890
mineral that was either in case in the

192
00:07:54,500 --> 00:07:52,050
dialysis barrier so as to prevent any

193
00:07:57,110 --> 00:07:54,510
cell mineral contact and these were

194
00:08:00,350 --> 00:07:57,120
compared to conditions where the mineral

195
00:08:05,050 --> 00:08:00,360
was available as free suspensions and in

196
00:08:08,300 --> 00:08:05,060
addition to this we also compared the

197
00:08:11,570 --> 00:08:08,310
compared these two conditions to another

198
00:08:13,160 --> 00:08:11,580
condition where we had an empty dialysis

199
00:08:14,330 --> 00:08:13,170
barrier added to free suspensions of

200
00:08:16,910 --> 00:08:14,340
Farah hydrate and this condition

201
00:08:19,040 --> 00:08:16,920
primarily served the purpose of ensuring

202
00:08:21,860 --> 00:08:19,050
that the the barrier itself did not pose

203
00:08:23,840 --> 00:08:21,870
any toxicity for growth now all of these

204
00:08:25,730 --> 00:08:23,850
conditions we examined as is but also in

205
00:08:29,060 --> 00:08:25,740
the presence of an artificial electron

206
00:08:32,150 --> 00:08:29,070
shuttle a QD s an artificial iron key

207
00:08:34,370 --> 00:08:32,160
later NTA and also cell free spent

208
00:08:36,230 --> 00:08:34,380
supernatant supposed to account for any

209
00:08:41,089 --> 00:08:36,240
endogenously produced shuttles of he

210
00:08:44,690 --> 00:08:41,099
laters so what we found from these

211
00:08:46,130 --> 00:08:44,700
results were that be delaney I was

212
00:08:49,940 --> 00:08:46,140
unable to grow without any mineral

213
00:08:51,800 --> 00:08:49,950

contact and that you'll notice we're

214
00:08:53,960 --> 00:08:51,810
looking at number of cells over time and

215
00:08:56,210 --> 00:08:53,970
that when the mineral was available as a

216
00:08:58,220 --> 00:08:56,220
free suspension regardless of whether a

217
00:09:01,040 --> 00:08:58,230
shuttle key later or cell free spent

218
00:09:01,280 --> 00:09:01,050
supernatant was added to the medium that

219
00:09:03,379 --> 00:09:01,290
the

220
00:09:05,110 --> 00:09:03,389
cells grew rapidly over time and showed

221
00:09:07,550 --> 00:09:05,120
no differences in the rates of growth

222
00:09:10,430 --> 00:09:07,560
whereas when the menorah was encased in

223
00:09:13,550 --> 00:09:10,440
a barrier that cells rapidly died or

224
00:09:16,220 --> 00:09:13,560
could barely sustain any growth now when

225
00:09:19,400 --> 00:09:16,230
we look at the FE 2 production over time

226
00:09:21,259 --> 00:09:19,410
for these experiments particularly for

227
00:09:22,639 --> 00:09:21,269
the experiments where free suspensions

228
00:09:24,920 --> 00:09:22,649
of Farrah hydride were made available

229
00:09:27,980 --> 00:09:24,930
with the addition of a shuttle Oki later

230
00:09:30,050 --> 00:09:27,990
or self-respond supernatant that only a

231
00:09:36,410 --> 00:09:30,060
few - production was stimulated upon

232
00:09:38,990 --> 00:09:36,420
addition of the shuttle a QD s so next

233
00:09:41,949 --> 00:09:39,000
we wanted to know given that this

234
00:09:44,720 --> 00:09:41,959
organism has these 17 C type cytochromes

235
00:09:48,350 --> 00:09:44,730
which c type cytochromes may be involved

236
00:09:52,249 --> 00:09:48,360
in iron reduction and so to do this we

237
00:09:54,710 --> 00:09:52,259
actually looked at we extracted the

238
00:09:57,170 --> 00:09:54,720

proteins from Farrah hydrate grown cells

239
00:10:01,460 --> 00:09:57,180
and compared them to the protein

240
00:10:04,550 --> 00:10:01,470
extracts of nitrate grown cells and we

241
00:10:06,980 --> 00:10:04,560
stained specific stains specifically for

242
00:10:09,730 --> 00:10:06,990
the cytochromes using a heme stain and

243
00:10:13,250 --> 00:10:09,740
here we found differential protein bands

244
00:10:16,370 --> 00:10:13,260
in in these two conditions which we

245
00:10:21,379 --> 00:10:16,380
excised digested and sent for mass spec

246
00:10:24,379 --> 00:10:21,389
and found that an ATM C Drive cytochrome

247
00:10:29,780 --> 00:10:24,389
was uniquely produced in the Farrah

248
00:10:32,180 --> 00:10:29,790
hydride grown cultures and 3 C type

249
00:10:35,000 --> 00:10:32,190
cytochromes 1/8 heme mono him and died

250
00:10:39,019 --> 00:10:35,010
him C type cytochrome were produced in

251
00:10:44,240 --> 00:10:39,029
either Farrah hydrate or nitrate grown

252
00:10:45,500 --> 00:10:44,250
cultures or both cultures rather so what

253
00:10:46,910 --> 00:10:45,510
are these C type cytochromes and I'm

254
00:10:51,439 --> 00:10:46,920
primarily going to focus on these two

255
00:10:52,670 --> 00:10:51,449
highlighted here in this next slide when

256
00:10:54,379 --> 00:10:52,680
we look think about these c TF

257
00:10:57,920 --> 00:10:54,389
cytochromes in the context of the genome

258
00:11:00,470 --> 00:10:57,930
of this organism we find that 11 of

259
00:11:03,710 --> 00:11:00,480
these 17 total c type cytochromes in

260
00:11:05,420 --> 00:11:03,720
this organism are these cytochromes are

261
00:11:08,559 --> 00:11:05,430
highlighted as yellow circles here and

262
00:11:12,530 --> 00:11:08,569
the number is the number of hims heme

263
00:11:14,840 --> 00:11:12,540

groups the the cytochromes have and the

264
00:11:15,110 --> 00:11:14,850
these eleven of these see that sairam's

265
00:11:17,870 --> 00:11:15,120
up

266
00:11:19,730 --> 00:11:17,880
are these for punitive operands depicted

267
00:11:24,110 --> 00:11:19,740
in these four colors here that encode

268
00:11:26,990 --> 00:11:24,120
these membrane reductase complexes for

269
00:11:28,970 --> 00:11:27,000
which we have really no homologues in

270
00:11:31,310 --> 00:11:28,980
other iron reducing general such as

271
00:11:34,340 --> 00:11:31,320
those of para baculum ferrell Globo

272
00:11:36,590 --> 00:11:34,350
Sergio Globus and more interestingly the

273
00:11:38,870 --> 00:11:36,600
two cytochromes that we found on the

274
00:11:42,220 --> 00:11:38,880
previous slide are actually the farah

275
00:11:44,570 --> 00:11:42,230
hydride condition see dep cytochrome is

276
00:11:47,060 --> 00:11:44,580
encoded by this gene right here

277
00:11:49,430 --> 00:11:47,070
the 7-8 form and just part of this

278
00:11:51,769 --> 00:11:49,440
period of operon that also in contains a

279
00:11:55,310 --> 00:11:51,779
gene that encodes a 13 heme c type

280
00:11:57,050 --> 00:11:55,320
cytochrome so and and here we see that

281
00:11:59,360 --> 00:11:57,060
this is the farah hydrate and nitrate

282
00:12:00,650 --> 00:11:59,370
culture where we see another a-team see

283
00:12:03,769 --> 00:12:00,660
that cytochrome that's part of this

284
00:12:08,090 --> 00:12:03,779
operon that has offs related to solve

285
00:12:10,760 --> 00:12:08,100
for reductases so i would be interesting

286
00:12:13,400 --> 00:12:10,770
to know what which genes are

287
00:12:15,110 --> 00:12:13,410
differentially expressed as well and

288
00:12:16,880 --> 00:12:15,120

also quantitatively determine the

289
00:12:19,550 --> 00:12:16,890
abundances of these proteins that are

290
00:12:20,240 --> 00:12:19,560
produced and that's part of future work

291
00:12:23,600 --> 00:12:20,250
for us

292
00:12:25,490 --> 00:12:23,610
so I want to quickly summarize what I've

293
00:12:28,310 --> 00:12:25,500
been able to share today with you and

294
00:12:30,140 --> 00:12:28,320
that that is that a wide range of nano

295
00:12:32,390 --> 00:12:30,150
phase iron oxides can be used for iron

296
00:12:36,199 --> 00:12:32,400
reduction at high temperatures and the

297
00:12:38,900 --> 00:12:36,209
key to recognizing what I want to

298
00:12:40,910 --> 00:12:38,910
emphasize here is that the part the the

299
00:12:42,560 --> 00:12:40,920
nano phase part of this is that you know

300
00:12:45,140 --> 00:12:42,570
we need to think about environmentally

301
00:12:46,699 --> 00:12:45,150
relevant phases in that the nano

302
00:12:50,030 --> 00:12:46,709
particular it phases are likely more

303
00:12:51,380 --> 00:12:50,040
environmentally relevant and that growth

304
00:12:53,060 --> 00:12:51,390
of reduction rates inversely correlated

305
00:12:54,620 --> 00:12:53,070
with oxide crystallinity in

306
00:12:57,140 --> 00:12:54,630
thermodynamic stability this is not

307
00:12:58,850 --> 00:12:57,150
surprising but that farah hydride a

308
00:13:02,079 --> 00:12:58,860
Cugini and lipid accrue site make

309
00:13:04,550 --> 00:13:02,089
interesting phases to further explore

310
00:13:07,329 --> 00:13:04,560
the end products of reduction depend

311
00:13:09,500 --> 00:13:07,339
upon oxide in Fe to flux and that

312
00:13:11,540 --> 00:13:09,510
magnetite fares phosphates and first

313
00:13:13,579 --> 00:13:11,550

carbonates can form the latter two of

314
00:13:15,650 --> 00:13:13,589
these to the best of our knowledge have

315
00:13:19,130 --> 00:13:15,660
not been reported for high-temperature

316
00:13:20,690 --> 00:13:19,140
iron reducers and so we'd be interested

317
00:13:25,400 --> 00:13:20,700
to see if this is a phenomenon that

318
00:13:27,380 --> 00:13:25,410
occurs overall additionally from a

319
00:13:29,000 --> 00:13:27,390
physiological standpoint cell mineral

320
00:13:30,500 --> 00:13:29,010
contact is required for reduction

321
00:13:33,500 --> 00:13:30,510
and that potentially novelty type

322
00:13:35,030 --> 00:13:33,510
cytochromes may be produced with Farah

323
00:13:36,800 --> 00:13:35,040
hydride relative to nitrate and these

324
00:13:38,830 --> 00:13:36,810
are looking into further using

325
00:13:41,330 --> 00:13:38,840
differential gene expression and

326
00:13:43,100 --> 00:13:41,340
quantitative proteomics experiments and

327
00:13:44,870 --> 00:13:43,110
with that I'd like to thank folks at

328
00:13:47,990 --> 00:13:44,880
UMass Amherst Mount Holyoke College as

329
00:13:49,520 --> 00:13:48,000
well as Brooker optics and also funding

330
00:13:58,700 --> 00:13:49,530
without which none of this work would be

331
00:14:04,820 --> 00:13:58,710
possible so thank you I think we have a

332
00:14:07,430 --> 00:14:04,830
question over here sorry I misunderstood

333
00:14:11,510 --> 00:14:07,440
something because you you studied the

334
00:14:15,590 --> 00:14:11,520
growth of the tombola microbe of the

335
00:14:19,450 --> 00:14:15,600
microorganisms on ferric minerals and

336
00:14:22,580 --> 00:14:19,460
then you showed most power spectra

337
00:14:25,730 --> 00:14:22,590
biotic and abiotic so what does that

338
00:14:28,790 --> 00:14:25,740

these two different spectra where do

339
00:14:32,480 --> 00:14:28,800
they correspond so the so the biotic

340
00:14:34,970 --> 00:14:32,490
spectra are taken from exponentially

341
00:14:38,660 --> 00:14:34,980
grown cells the minerals that were

342
00:14:41,420 --> 00:14:38,670
transformed after cells had been cells

343
00:14:44,870 --> 00:14:41,430
grew on those minerals and the abiotic

344
00:14:47,090 --> 00:14:44,880
abiotic condition is where the there

345
00:14:49,970 --> 00:14:47,100
were no cells added to the same exact

346
00:14:53,510 --> 00:14:49,980
set up okay so it is the same descent

347
00:14:55,790 --> 00:14:53,520
mineral just before the growth and after

348
00:14:58,610 --> 00:14:55,800
the growth no no it is it's actually

349
00:15:00,380 --> 00:14:58,620
heat reacted so it's so these are grown

350
00:15:04,850 --> 00:15:00,390
these are cultures grown at 90 degrees

351
00:15:06,830 --> 00:15:04,860
Celsius in anaerobic cultures and so the

352
00:15:10,010 --> 00:15:06,840
abiotic in the most power spectra

353
00:15:12,980 --> 00:15:10,020
reflect heat transformations that may be

354
00:15:15,790 --> 00:15:12,990
occurring for the same duration that we

355
00:15:22,550 --> 00:15:15,800
see any sort of biogenic transformation

356
00:15:23,870 --> 00:15:22,560
does that make sense yes she we have

357
00:15:28,070 --> 00:15:23,880
time for maybe one quick question if

358
00:15:29,700 --> 00:15:28,080
there's others all right thank you thank