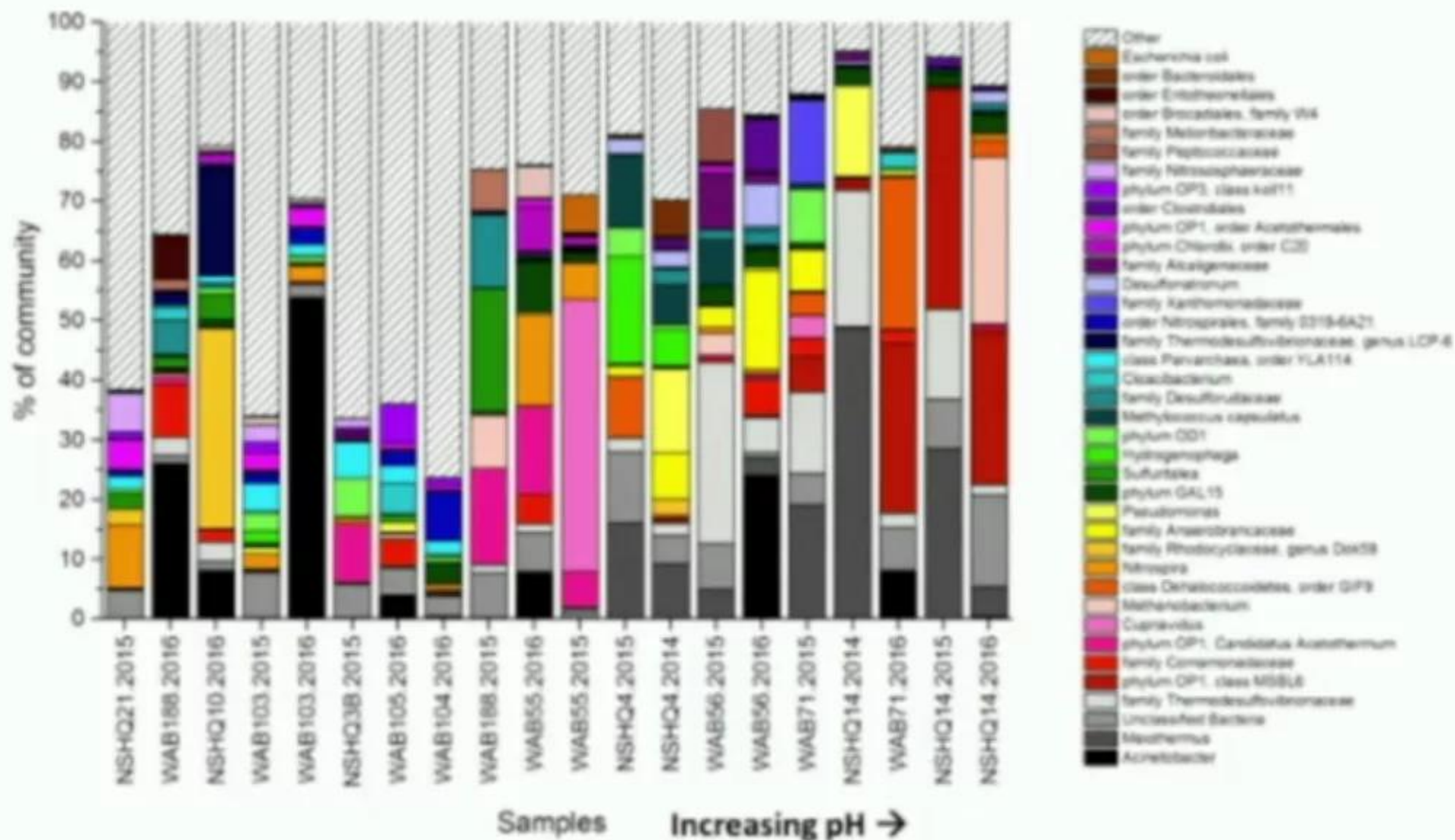


# Diverse Microbial Communities and Metabolisms



1  
00:00:11,030 --> 00:00:08,960  
I'm Katie rembert I'm a second year PhD

2  
00:00:12,680 --> 00:00:11,040  
student here at Colorado Boulder working

3  
00:00:16,580 --> 00:00:12,690  
with Alexis Templeton as part of the

4  
00:00:18,019 --> 00:00:16,590  
rock powered life nei team and today I'm

5  
00:00:21,170 --> 00:00:18,029  
going to be presenting some of my

6  
00:00:23,120 --> 00:00:21,180  
initial work on geologic and hydrologic

7  
00:00:24,679 --> 00:00:23,130  
controls on the habitability of

8  
00:00:27,920 --> 00:00:24,689  
terrestrial serpentine izing

9  
00:00:30,290 --> 00:00:27,930  
environments and so now you're probably

10  
00:00:31,820 --> 00:00:30,300  
all very familiar with the serpent

11  
00:00:33,650 --> 00:00:31,830  
anization reaction but this is really

12  
00:00:35,540 --> 00:00:33,660  
the core geologic process that's behind

13  
00:00:37,600 --> 00:00:35,550

my research and like Hannah mentioned

14

00:00:39,860 --> 00:00:37,610

what I'm really interested in is the

15

00:00:42,010 --> 00:00:39,870

oxidation of iron coupled to the

16

00:00:46,190 --> 00:00:42,020

reduction of water to form hydrogen gas

17

00:00:49,850 --> 00:00:46,200

because as is as you can see here from

18

00:00:52,040 --> 00:00:49,860

this electron tower that hydrogen is a

19

00:00:55,040 --> 00:00:52,050

powerful reductant it can act as a

20

00:00:58,220 --> 00:00:55,050

strong potential electron donor for

21

00:01:00,709 --> 00:00:58,230

microbial metabolism and of course this

22

00:01:04,579 --> 00:01:00,719

has great astrobiological implications

23

00:01:07,820 --> 00:01:04,589

we have detected serpentine on noachian

24

00:01:10,700 --> 00:01:07,830

age outcrops on Mars and from

25

00:01:12,770 --> 00:01:10,710

geochemical modeling of the plumes from

26  
00:01:16,190 --> 00:01:12,780  
Enceladus we believe that the ph of the

27  
00:01:18,200 --> 00:01:16,200  
subsurface ocean is 11 or 12 which could

28  
00:01:21,050 --> 00:01:18,210  
only be explained by serpentinization

29  
00:01:23,630 --> 00:01:21,060  
processes and so if serpent anization

30  
00:01:26,780 --> 00:01:23,640  
did happen in the geologic past in

31  
00:01:28,520 --> 00:01:26,790  
either Mars or Enceladus that suggests

32  
00:01:31,580 --> 00:01:28,530  
potential habitability of these

33  
00:01:33,469 --> 00:01:31,590  
environments and so I want to just bring

34  
00:01:35,539 --> 00:01:33,479  
up the definition of habitability

35  
00:01:38,899 --> 00:01:35,549  
traditionally in astrobiology you'll

36  
00:01:41,899 --> 00:01:38,909  
find a binary definition and so in this

37  
00:01:44,450 --> 00:01:41,909  
review paper by Kyle at all in 2016 and

38  
00:01:46,310 --> 00:01:44,460

astrobiology Journal they say the

39

00:01:49,039 --> 00:01:46,320

ability of an environment to support the

40

00:01:52,639 --> 00:01:49,049

activity of at least one known organism

41

00:01:56,030 --> 00:01:52,649

and so on earth this definition doesn't

42

00:01:57,770 --> 00:01:56,040

work quite as well and so if you're

43

00:01:59,810 --> 00:01:57,780

comparing the Amazon rainforest to the

44

00:02:03,020 --> 00:01:59,820

Atacama Desert yes they are both

45

00:02:04,609 --> 00:02:03,030

habitable but there's varying degrees so

46

00:02:07,150 --> 00:02:04,619

the Atacama Desert is not as

47

00:02:10,969 --> 00:02:07,160

habitable as the Amazon rainforest and

48

00:02:13,820 --> 00:02:10,979

so habitability at least on earth is a

49

00:02:16,370 --> 00:02:13,830

continuum life is ubiquitous

50

00:02:17,930 --> 00:02:16,380

and the distribution of life varies as a

51  
00:02:20,750 --> 00:02:17,940  
function of geology chemistry and

52  
00:02:23,510 --> 00:02:20,760  
physics these controlled amount of

53  
00:02:24,950 --> 00:02:23,520  
energy the amount of nutrients chemical

54  
00:02:28,310 --> 00:02:24,960  
compounds such as water that's available

55  
00:02:32,660 --> 00:02:28,320  
to life and so one of the aims of this

56  
00:02:34,970 --> 00:02:32,670  
work is to be able to use geologic and

57  
00:02:36,320 --> 00:02:34,980  
hydrologic controls to try to predict

58  
00:02:38,450 --> 00:02:36,330  
how that would influence the

59  
00:02:41,810 --> 00:02:38,460  
habitability of an environment so in

60  
00:02:43,550 --> 00:02:41,820  
trying to plan a mission where would you

61  
00:02:46,280 --> 00:02:43,560  
want to search for life what would be

62  
00:02:48,790 --> 00:02:46,290  
the most habitable environment within a

63  
00:02:52,670 --> 00:02:48,800

terrestrial astre Penton izing ecosystem

64

00:02:55,070 --> 00:02:52,680

and so my natural laboratory is this

65

00:02:57,320 --> 00:02:55,080

mail if you light in oman oman is

66

00:02:59,710 --> 00:02:57,330

locates located southeast of Saudi

67

00:03:02,750 --> 00:02:59,720

Arabia and the Arabian Peninsula and

68

00:03:05,150 --> 00:03:02,760

here's Hannah mentioned we have oceanic

69

00:03:07,310 --> 00:03:05,160

crust Olga Bros and upper mantle

70

00:03:10,460 --> 00:03:07,320

prototypes that were emplaced on to the

71

00:03:13,130 --> 00:03:10,470

continent during the Cretaceous and you

72

00:03:16,040 --> 00:03:13,140

can kind of see a resemblance to an

73

00:03:18,440 --> 00:03:16,050

extraterrestrial environment with the

74

00:03:20,360 --> 00:03:18,450

smell a few light in the top image here

75

00:03:23,600 --> 00:03:20,370

and you can see there's very little

76

00:03:27,199 --> 00:03:23,610

plant cover and it's a very arid climate

77

00:03:29,900 --> 00:03:27,209

and so in Oman we have a unique

78

00:03:33,170 --> 00:03:29,910

opportunity to sample deep subsurface

79

00:03:35,270 --> 00:03:33,180

fluids domani government drilled Wells

80

00:03:38,120 --> 00:03:35,280

into the ophiolite in search for water

81

00:03:40,759 --> 00:03:38,130

resources for their country which was

82

00:03:44,449 --> 00:03:40,769

not successful because most of these

83

00:03:47,420 --> 00:03:44,459

waters are above a pH of 11 but these

84

00:03:49,580 --> 00:03:47,430

wells span the crustal mantle transition

85

00:03:52,640 --> 00:03:49,590

and so I've labeled the wells according

86

00:03:56,479 --> 00:03:52,650

to the rock type that they are located

87

00:03:58,640 --> 00:03:56,489

in and so we are able to sample various

88

00:04:01,490 --> 00:03:58,650

lithologies both gabbro and prototype

89

00:04:04,420 --> 00:04:01,500

across various hydrological regimes and

90

00:04:07,670 --> 00:04:04,430

I've labeled contact wells here in pink

91

00:04:10,039 --> 00:04:07,680

I distinguish these separately because

92

00:04:11,509 --> 00:04:10,049

they sit right between the gabbro and

93

00:04:15,110 --> 00:04:11,519

the pretty tight so it's difficult to

94

00:04:18,650 --> 00:04:15,120

tell what the water is actually reacting

95

00:04:21,620 --> 00:04:18,660

with and so in these wells we use a deep

96

00:04:23,570 --> 00:04:21,630

submersible pump to retrieve deep fluids

97

00:04:26,140 --> 00:04:23,580

for geochemical analysis and then we

98

00:04:27,939 --> 00:04:26,150

also filter five to ten liters of fluid

99

00:04:30,310 --> 00:04:27,949

to concentrate biomass so that we can

100

00:04:35,020 --> 00:04:30,320

sequence the DNA of any organisms that

101  
00:04:37,779 --> 00:04:35,030  
are living in the subsurface and so what

102  
00:04:40,060 --> 00:04:37,789  
we see at least geochemical e is highly

103  
00:04:41,920 --> 00:04:40,070  
variable chemistry and so I show here a

104  
00:04:43,689 --> 00:04:41,930  
principal component analysis of

105  
00:04:46,560 --> 00:04:43,699  
geochemical parameters that were

106  
00:04:49,749 --> 00:04:46,570  
measured all three years of our sampling

107  
00:04:52,480 --> 00:04:49,759  
we only sample 12 wells but we were

108  
00:04:53,980 --> 00:04:52,490  
turned in the winter for three years so

109  
00:04:57,189 --> 00:04:53,990  
we have a total of twenty deep well

110  
00:04:58,960 --> 00:04:57,199  
samples and I plotted the variable

111  
00:05:02,080 --> 00:04:58,970  
loadings as vectors on this principle

112  
00:05:04,180 --> 00:05:02,090  
component analysis to show the

113  
00:05:05,830 --> 00:05:04,190

relationship of each of these chemical

114

00:05:08,500 --> 00:05:05,840

parameters to the first and second

115

00:05:11,680 --> 00:05:08,510

principle components and so principal

116

00:05:14,560 --> 00:05:11,690

component one explains 52.3 percent of

117

00:05:16,900 --> 00:05:14,570

the variance and what you see is kind of

118

00:05:19,750 --> 00:05:16,910

these fluid chemistry's parsing out

119

00:05:24,760 --> 00:05:19,760

based on chemistry to the right you see

120

00:05:27,580 --> 00:05:24,770

a higher pH calcium rich fluids which I

121

00:05:30,370 --> 00:05:27,590

labeled here as alkaline prototype which

122

00:05:32,439 --> 00:05:30,380

can be distinguished from the pink

123

00:05:34,480 --> 00:05:32,449

pretty tight reacted fluids that are

124

00:05:41,080 --> 00:05:34,490

more silica rich and have a much lower

125

00:05:43,270 --> 00:05:41,090

pH and so and so this variable

126

00:05:45,520 --> 00:05:43,280

geochemistry can easily be explained by

127

00:05:48,100 --> 00:05:45,530

differences in depth and extent of water

128

00:05:50,469 --> 00:05:48,110

rock reaction and so in the shallow

129

00:05:52,360 --> 00:05:50,479

subsurface you would have weathering

130

00:05:55,450 --> 00:05:52,370

reactions in contact with atmospheric

131

00:05:57,279 --> 00:05:55,460

oxygen and carbon dioxide and so you

132

00:05:59,980 --> 00:05:57,289

would whether your magnesium bearing

133

00:06:02,770 --> 00:05:59,990

minerals enriching fluids and magnesium

134

00:06:05,290 --> 00:06:02,780

and bicarbonate and as Hannah mentioned

135

00:06:08,680 --> 00:06:05,300

you're also increasing the pH these

136

00:06:10,899 --> 00:06:08,690

weathering reactions consume protons and

137

00:06:13,870 --> 00:06:10,909

at least in the shallow subsurface this

138

00:06:16,710 --> 00:06:13,880

brings a pH to about eight or nine but

139

00:06:20,020 --> 00:06:16,720

if these fluids percolate deeper and

140

00:06:21,760 --> 00:06:20,030

lose contact with the atmosphere this is

141

00:06:25,089 --> 00:06:21,770

when we really see serpentization

142

00:06:27,100 --> 00:06:25,099

processes happening your magnesium is

143

00:06:28,719 --> 00:06:27,110

preferentially going into secondary

144

00:06:31,240 --> 00:06:28,729

minerals such as serpentine and brew

145

00:06:34,089 --> 00:06:31,250

site so your ritching fluids and calcium

146

00:06:38,050 --> 00:06:34,099

you're increasing the pH to about at NRL

147

00:06:39,399 --> 00:06:38,060

to about 10 and 11 maybe 12 and because

148

00:06:41,439 --> 00:06:39,409

of that most of your di

149

00:06:43,749 --> 00:06:41,449

see is in the form of the carbonate

150

00:06:45,429 --> 00:06:43,759

anion and no longer bicarbonate and so

151  
00:06:47,529 --> 00:06:45,439  
you can precipitate out carbonate

152  
00:06:49,929 --> 00:06:47,539  
minerals and this really lowers the

153  
00:06:51,549 --> 00:06:49,939  
dissolved inorganic carbon concentration

154  
00:06:53,229 --> 00:06:51,559  
which would impact biology would be

155  
00:06:56,829 --> 00:06:53,239  
really hard to fix carbon if there's not

156  
00:06:59,290 --> 00:06:56,839  
much carbon to fix and I just want to

157  
00:07:01,329 --> 00:06:59,300  
point out that most of the previous work

158  
00:07:03,059 --> 00:07:01,339  
in these terrestrial systems has focused

159  
00:07:05,350 --> 00:07:03,069  
solely on where these deep fluids

160  
00:07:07,689 --> 00:07:05,360  
re-emerged at the surface and seeps in

161  
00:07:10,359 --> 00:07:07,699  
contact with oxygen so the work I'm

162  
00:07:12,489 --> 00:07:10,369  
doing really expands a habitability

163  
00:07:14,979 --> 00:07:12,499

assessment not only into the subsurface

164

00:07:16,869 --> 00:07:14,989

but i was looking at highly variable

165

00:07:21,279 --> 00:07:16,879

fluid chemistry and not just focusing on

166

00:07:23,679 --> 00:07:21,289

fluids that are ph 11 and 12 and so i

167

00:07:24,850 --> 00:07:23,689

end up seeing very diverse microbial

168

00:07:27,339 --> 00:07:24,860

communities don't worry i'm not going to

169

00:07:31,059 --> 00:07:27,349

go into particularly what organisms we

170

00:07:32,889 --> 00:07:31,069

see i just want to point out that we can

171

00:07:35,589 --> 00:07:32,899

predict at least somewhat what

172

00:07:39,129 --> 00:07:35,599

metabolisms might be occurring in the

173

00:07:41,019 --> 00:07:39,139

subsurface and from the looks of just

174

00:07:43,209 --> 00:07:41,029

looking at the what organisms that are

175

00:07:45,879 --> 00:07:43,219

there potentially we have hydrogen

176

00:07:48,579 --> 00:07:45,889

oxidation meth an agenda TSA's osita

177

00:07:51,509 --> 00:07:48,589

genesis sulfate reduction fermentation

178

00:07:54,279 --> 00:07:51,519

denitrification so very diverse

179

00:07:56,859 --> 00:07:54,289

metabolisms and just to point out we do

180

00:07:59,619 --> 00:07:56,869

see life so this isn't at a surface

181

00:08:01,659 --> 00:07:59,629

system where we have oxygen providing an

182

00:08:04,540 --> 00:08:01,669

accident these are probably very

183

00:08:07,269 --> 00:08:04,550

stressed fluids and we are easily able

184

00:08:10,779 --> 00:08:07,279

to sequence the DNA just using a basic

185

00:08:13,149 --> 00:08:10,789

power soil DNA kit concentrating just

186

00:08:17,319 --> 00:08:13,159

five to ten liters of fluid we can get

187

00:08:20,079 --> 00:08:17,329

great results but there are huge impacts

188

00:08:22,719 --> 00:08:20,089

on diversity with pH and so here I've

189

00:08:24,819 --> 00:08:22,729

plotted pH versus richness richness is

190

00:08:27,939 --> 00:08:24,829

just the total number of microbial

191

00:08:29,259 --> 00:08:27,949

species detected in a sample and as you

192

00:08:31,540 --> 00:08:29,269

can see there's a strong negative

193

00:08:33,879 --> 00:08:31,550

correlation we can't say this is a

194

00:08:35,649 --> 00:08:33,889

causation because pH co varies with a

195

00:08:39,969 --> 00:08:35,659

lot of other geochemical parameters such

196

00:08:43,929 --> 00:08:39,979

as calcium but you do know that these

197

00:08:45,549 --> 00:08:43,939

the ph of the fluids that you sample has

198

00:08:49,629 --> 00:08:45,559

a good indication of what type of

199

00:08:52,629 --> 00:08:49,639

diversity you might see and as you would

200

00:08:53,380 --> 00:08:52,639

expect different fluid chemistry's host

201  
00:08:57,130 --> 00:08:53,390  
different my

202  
00:09:00,340 --> 00:08:57,140  
Chromo communities I show here an N MDS

203  
00:09:02,470 --> 00:09:00,350  
plot to ordinate the samples based on

204  
00:09:04,690 --> 00:09:02,480  
microbial community similarities so

205  
00:09:06,550 --> 00:09:04,700  
samples that plot closely together have

206  
00:09:09,310 --> 00:09:06,560  
more similar communities than samples

207  
00:09:12,880 --> 00:09:09,320  
that plot very far and the size of the

208  
00:09:15,280 --> 00:09:12,890  
sample point it correlates to the

209  
00:09:17,470 --> 00:09:15,290  
richness and so what we see from this is

210  
00:09:19,600 --> 00:09:17,480  
that geologic context and the extent of

211  
00:09:23,440 --> 00:09:19,610  
water action really control the

212  
00:09:25,900 --> 00:09:23,450  
microbial ecology our elkland prototype

213  
00:09:27,460 --> 00:09:25,910

the shallow reaction and the gabbro have

214

00:09:29,140 --> 00:09:27,470

very similar communities which makes

215

00:09:31,630 --> 00:09:29,150

sense because on the principle component

216

00:09:34,150 --> 00:09:31,640

analysis geochemistry they plotted right

217

00:09:36,280 --> 00:09:34,160

next to each other we saw that the hyper

218

00:09:39,100 --> 00:09:36,290

elkland prototype fluids had a very

219

00:09:40,570 --> 00:09:39,110

disparate geochemistry and they plot on

220

00:09:41,800 --> 00:09:40,580

the opposite side of this ordination

221

00:09:43,630 --> 00:09:41,810

they have a very different microbial

222

00:09:45,370 --> 00:09:43,640

communities but I think most

223

00:09:47,560 --> 00:09:45,380

interestingly is that these contact

224

00:09:50,890 --> 00:09:47,570

fluids which on the PCA had a very

225

00:09:52,690 --> 00:09:50,900

variable geochemistry actually have a

226

00:09:54,940 --> 00:09:52,700

very unique microbial community

227

00:09:57,550 --> 00:09:54,950

composition compared to any other fluid

228

00:10:00,310 --> 00:09:57,560

type and so just to bring this all

229

00:10:03,100 --> 00:10:00,320

together and kind of expand a Hydra

230

00:10:05,590 --> 00:10:03,110

geochemical model of habitability there

231

00:10:08,290 --> 00:10:05,600

are a few sites of interest so in this

232

00:10:10,300 --> 00:10:08,300

study we sampled the shallow prototype

233

00:10:12,280 --> 00:10:10,310

fluids and deep fluids but we didn't

234

00:10:14,920 --> 00:10:12,290

really capture a transition so we just

235

00:10:16,630 --> 00:10:14,930

have these two end members but

236

00:10:18,610 --> 00:10:16,640

theoretically somewhere in the

237

00:10:20,830 --> 00:10:18,620

subsurface you have to have a transition

238

00:10:21,910 --> 00:10:20,840

from a more oxidized fluid to a more

239

00:10:24,610 --> 00:10:21,920

reduced and that would be very

240

00:10:26,200 --> 00:10:24,620

interesting biologically because that

241

00:10:28,690 --> 00:10:26,210

chemical disequilibrium would provide

242

00:10:31,150 --> 00:10:28,700

energy for microbial metabolism so in

243

00:10:32,800 --> 00:10:31,160

the future we're trying to find Wells

244

00:10:35,200 --> 00:10:32,810

and hopefully with a Mon drilling

245

00:10:37,600 --> 00:10:35,210

project maybe we can drill well that

246

00:10:39,790 --> 00:10:37,610

captures some of the microbiology in

247

00:10:42,490 --> 00:10:39,800

those transitional fluids but also as I

248

00:10:45,160 --> 00:10:42,500

just mentioned I am interested in these

249

00:10:48,280 --> 00:10:45,170

contact fluids so I have added gabbro to

250

00:10:50,050 --> 00:10:48,290

this Hydra geochemical model and at

251

00:10:53,290 --> 00:10:50,060

these contact fluids you have a huge

252

00:10:55,600 --> 00:10:53,300

change in permeability so gay bros are

253

00:10:57,820 --> 00:10:55,610

much more permeable you have these deep

254

00:11:00,940 --> 00:10:57,830

hyper elkland prototype foods injecting

255

00:11:03,100 --> 00:11:00,950

into gabbro which is facilitating mixing

256

00:11:06,250 --> 00:11:03,110

and again that's chemical disequilibrium

257

00:11:07,120 --> 00:11:06,260

that could support life and during this

258

00:11:08,680 --> 00:11:07,130

injection you're actually

259

00:11:11,530 --> 00:11:08,690

forcing these fluids up to the surface

260

00:11:13,750 --> 00:11:11,540

so astro biologically if you're looking

261

00:11:15,490 --> 00:11:13,760

at a serpentine outcrop on Mars and you

262

00:11:17,350 --> 00:11:15,500

see a contact between pretty tight and

263

00:11:20,050 --> 00:11:17,360

gabbro maybe that's a place where you

264

00:11:26,080 --> 00:11:20,060

would potentially find near-surface bio

265

00:11:40,660 --> 00:11:26,090

signatures and with that if any

266

00:11:42,700 --> 00:11:40,670

questions questions for Katie the risk

267

00:11:44,680 --> 00:11:42,710

of something obsessive I stucco mamonas

268

00:11:46,120 --> 00:11:44,690

and reach that high pH in your cultures

269

00:11:47,800 --> 00:11:46,130

to learn so I'm thinking maybe there's

270

00:11:51,330 --> 00:11:47,810

something interesting there when you

271

00:11:53,680 --> 00:11:51,340

look at the 16s yeah you see when you go

272

00:11:55,600 --> 00:11:53,690

to the higher pH is you have more

273

00:12:01,030 --> 00:11:55,610

abundance of coma Mona's compared to the

274

00:12:04,090 --> 00:12:01,040

other which is exactly what Stu the seed

275

00:12:07,060 --> 00:12:04,100

and I thought it's interesting the coma

276

00:12:10,900 --> 00:12:07,070

Mona Dacia the three you at higher pH is

277

00:12:12,850 --> 00:12:10,910

the same thing as your isolates yes so

278

00:12:14,440 --> 00:12:12,860

there does seem to be at least for my

279

00:12:17,140 --> 00:12:14,450

dad I didn't go into this and this talk

280

00:12:19,870 --> 00:12:17,150

but a core similarity to at least these

281

00:12:21,520 --> 00:12:19,880

deep hyper alkaline prototype fluids to

282

00:12:24,490 --> 00:12:21,530

other serpent enticing systems and even

283

00:12:26,860 --> 00:12:24,500

to trust us repented izing seeps but i

284

00:12:29,200 --> 00:12:26,870

actually do see i guess some species

285

00:12:30,970 --> 00:12:29,210

that aren't commonly associated with

286

00:12:33,130 --> 00:12:30,980

other trust Joe serpent izing systems

287

00:12:35,950 --> 00:12:33,140

like thermode a self over B Rene say and

288

00:12:37,240 --> 00:12:35,960

mayo thermos may a thermos has found its

289

00:12:39,310 --> 00:12:37,250

surface heaps and thought to be aerobic

290

00:12:41,590 --> 00:12:39,320

but I only find it in my deep fluid so

291

00:12:42,760 --> 00:12:41,600

it's interesting there is a core

292

00:12:43,900 --> 00:12:42,770

similarity but there's also a lot of

293

00:12:46,120 --> 00:12:43,910

differences to what other people are

294

00:12:47,860 --> 00:12:46,130

seeing and yeah I'm one more question

295

00:12:50,890 --> 00:12:47,870

attention one more question is the rota

296

00:12:52,660 --> 00:12:50,900

cycle each other to detect in the NS HQ

297

00:12:57,190 --> 00:12:52,670

do you know the characteristics of that

298

00:13:04,510 --> 00:12:57,200

site and I say to you which one 410 and

299

00:13:07,930 --> 00:13:04,520

it's HQ 10 no I do not well NS HQ

300

00:13:10,120 --> 00:13:07,940

tenants a contact well we do weren't

301

00:13:12,130 --> 00:13:10,130

able to measure any reduce software

302

00:13:16,270 --> 00:13:12,140

species as some of those roto cycle ACR

303

00:13:18,430 --> 00:13:16,280

I'm involved in software cycling but

304

00:13:21,160 --> 00:13:18,440

that's like a pH of about eight

305

00:13:23,380 --> 00:13:21,170

okay yeah and what dude can you have an

306

00:13:26,620 --> 00:13:23,390

idea of what so there could be hydrogen

307

00:13:31,000 --> 00:13:26,630

oxidation coupled to metal reduction

308

00:13:33,880 --> 00:13:31,010

there so in most of these lower ph foods

309

00:13:35,620 --> 00:13:33,890

it seems like you have nitrate as the

310

00:13:37,210 --> 00:13:35,630

primary electron acceptor but you could

311

00:13:39,340 --> 00:13:37,220

have hydrogen oxidation coupled to

312

00:13:41,620 --> 00:13:39,350

nitrate but we don't actually detect

313

00:13:43,450 --> 00:13:41,630

hydrogen in the that fluid but it could

314

00:14:00,340 --> 00:13:43,460

be below the detection limit drawn down

315

00:14:02,350 --> 00:14:00,350

by microorganisms thank you I may be

316

00:14:03,730 --> 00:14:02,360

confusing concepts and maybe reaching a

317

00:14:05,440 --> 00:14:03,740

little bit on this one but I'm just

318

00:14:06,970 --> 00:14:05,450

noticing that as you were mentioning

319

00:14:09,010 --> 00:14:06,980

there was a correlation is saying that

320

00:14:12,310 --> 00:14:09,020

the authentic relation saying that there

321

00:14:14,800 --> 00:14:12,320

was more biodiversity at lower more

322

00:14:17,590 --> 00:14:14,810

acidic ph s and i realized that they may

323

00:14:19,750 --> 00:14:17,600

have more ideas may have more hydrogen

324

00:14:22,360 --> 00:14:19,760

concentrations and the hydrogen has

325

00:14:24,760 --> 00:14:22,370

electron donation is there a reason why

326

00:14:26,910 --> 00:14:24,770

a high electron donation and or hydrogen

327

00:14:30,670 --> 00:14:26,920

would actually be an increase of

328

00:14:33,010 --> 00:14:30,680

actually a biodiversity per se so it's

329

00:14:34,660 --> 00:14:33,020

hydrogen gas that's the great electron

330

00:14:37,540 --> 00:14:34,670

donor for metabolism we see that in the

331

00:14:39,160 --> 00:14:37,550

really high pH fluids but for as for pH

332

00:14:41,440 --> 00:14:39,170

being at a high pH is really stressful

333

00:14:44,530 --> 00:14:41,450

for microorganism you need a proton pump

334

00:14:47,380 --> 00:14:44,540

to be able to have metabolism and so

335

00:14:50,140 --> 00:14:47,390

somehow they're having to compensate for

336

00:14:54,190 --> 00:14:50,150

the lack of protons in those fluids to

337

00:14:57,550 --> 00:14:54,200

be able to live at all and so when i say

338

00:15:00,490 --> 00:14:57,560

more it's there still elkland so it's

339

00:15:02,320 --> 00:15:00,500

like a ph 8 to 9 but that's way less

340

00:15:04,570 --> 00:15:02,330

stressful to my our microorganism you'd

341

00:15:06,310 --> 00:15:04,580

expect many more microorganisms to be

342

00:15:18,870 --> 00:15:06,320

able to adapt to that type of setting as

343

00:15:24,520 --> 00:15:22,090

thank you thank you add a related

344

00:15:26,710 --> 00:15:24,530

question i was wondering in terms of

345

00:15:29,140 --> 00:15:26,720

diversity is there a cut off into

346

00:15:31,930 --> 00:15:29,150

revocable threshold when you go below

347

00:15:34,630 --> 00:15:31,940

the ph's that you showed today in terms

348

00:15:36,270 --> 00:15:34,640

of large amounts of diversity what do

349

00:15:38,230 --> 00:15:36,280

you see in terms of the more acidic

350

00:15:40,570 --> 00:15:38,240

systems that you're not necessarily

351

00:15:43,450 --> 00:15:40,580

looking at in this study so i would say

352

00:15:45,370 --> 00:15:43,460

usually phu in most environments you

353

00:15:46,990 --> 00:15:45,380

wouldn't see such a gradient of pH and

354

00:15:49,810 --> 00:15:47,000

pH wouldn't necessarily be your

355

00:15:51,400 --> 00:15:49,820

controlling factor so this is a system

356

00:15:54,400 --> 00:15:51,410

or look talking about an oligotrophic

357

00:15:56,080 --> 00:15:54,410

groundwater system there probably isn't

358

00:15:58,870 --> 00:15:56,090

a lot of organic carbon we did measure

359

00:16:02,080 --> 00:15:58,880

organic acids and they're like in micro

360

00:16:03,330 --> 00:16:02,090

molar concentrations but those possibly

361

00:16:05,470 --> 00:16:03,340

arose from serpent anization

362

00:16:07,750 --> 00:16:05,480

photosynthesis we have no idea at this

363

00:16:09,580 --> 00:16:07,760

point but compared to like an organic

364

00:16:11,710 --> 00:16:09,590

rich system you can support a lot more

365

00:16:15,820 --> 00:16:11,720

diversity just because you have a lot

366

00:16:17,530 --> 00:16:15,830

more energy so at our low pH wells that

367

00:16:20,020 --> 00:16:17,540

are less stressful to the microorganisms

368

00:16:22,090 --> 00:16:20,030

there's not many electron donors that we

369

00:16:24,370 --> 00:16:22,100

know of that are in those fluids to

370

00:16:25,990 --> 00:16:24,380

support life and so there are some

371

00:16:28,060 --> 00:16:26,000

organic molecules so there's some

372

00:16:29,830 --> 00:16:28,070

heterotrophic organisms there's possibly

373

00:16:33,370 --> 00:16:29,840

hydrogen that's just being drawn down

374

00:16:37,300 --> 00:16:33,380

but there actually isn't much to support

375

00:16:40,180 --> 00:16:37,310

life there it's freshwater so you would

376

00:16:43,000 --> 00:16:40,190

expect an even greater diversity on the

377

00:16:50,110 --> 00:16:43,010

scale of all life looking at anything