



1
00:00:00,790 --> 00:00:07,320

[Music]

2
00:00:11,250 --> 00:00:09,140

[Applause]

3
00:00:13,289 --> 00:00:11,260

my name is Sandra I first want to

4
00:00:16,199 --> 00:00:13,299

acknowledge some of my co-authors the

5
00:00:18,870 --> 00:00:16,209

notorious story hauler toe McCallum at

6
00:00:20,460 --> 00:00:18,880

Cibola LASP and mark Alperin at UNC

7
00:00:22,590 --> 00:00:20,470

Chapel Hill also and acknowledged my

8
00:00:24,150 --> 00:00:22,600

funding source Rock powered life not

9
00:00:25,109 --> 00:00:24,160

only for money but for their patience

10
00:00:28,800 --> 00:00:25,119

and building a very cool community

11
00:00:32,370 --> 00:00:28,810

around subsurface life so Rica this

12
00:00:34,530 --> 00:00:32,380

morning and nor EHS now made a really

13
00:00:37,620 --> 00:00:34,540

good explanation as to explaining the

14

00:00:39,930 --> 00:00:37,630

value of subsurface biology or geo

15

00:00:41,549 --> 00:00:39,940

microbiology to assess the possibility

16

00:00:42,810 --> 00:00:41,559

of life on ocean worlds so that's what

17

00:00:45,029 --> 00:00:42,820

I'm really interested in is how can we

18

00:00:49,080 --> 00:00:45,039

quantify this concept of habitability

19

00:00:50,729 --> 00:00:49,090

for methanogens and it's important

20

00:00:53,369 --> 00:00:50,739

because in the absence of oxygen at

21

00:00:55,139 --> 00:00:53,379

least on earth these these subsurface

22

00:00:56,430 --> 00:00:55,149

environments I extremely devoid in

23

00:00:58,110 --> 00:00:56,440

energy there's a really low energy

24

00:01:00,090 --> 00:00:58,120

environments rights about six orders of

25

00:01:02,700 --> 00:01:00,100

magnitude that separate that energy

26
00:01:04,229 --> 00:01:02,710
available to photosynthesizers compared

27
00:01:06,030 --> 00:01:04,239
to chemo synthesizers so it's really

28
00:01:09,570 --> 00:01:06,040
important to us as well the energy in

29
00:01:11,700 --> 00:01:09,580
the subsurface and the disconnection

30
00:01:13,319 --> 00:01:11,710
between geology and biology has been

31
00:01:14,700 --> 00:01:13,329
made by many people during this

32
00:01:16,710 --> 00:01:14,710
conference with this conference in

33
00:01:19,020 --> 00:01:16,720
particular connecting the process of

34
00:01:21,510 --> 00:01:19,030
serpentinization which is a reaction of

35
00:01:23,700 --> 00:01:21,520
water and rocks certainly not limited to

36
00:01:25,950 --> 00:01:23,710
the earth and one of the cool byproduct

37
00:01:28,200 --> 00:01:25,960
of this of this geo chemical reaction is

38
00:01:30,990 --> 00:01:28,210

the production of hydrogen and it also

39

00:01:33,600 --> 00:01:31,000

produces very alkaline water and then

40

00:01:35,370 --> 00:01:33,610

the coupling is obvious by the fact that

41

00:01:37,020 --> 00:01:35,380

hydrogen is a great electron donor and

42

00:01:40,440 --> 00:01:37,030

bugs I figured out how to use it to

43

00:01:42,870 --> 00:01:40,450

reduce co₂ to methane but Deb Kelly

44

00:01:46,889 --> 00:01:42,880

warned us in some of our lost city

45

00:01:49,469 --> 00:01:46,899

papers that organisms living in vents so

46

00:01:51,510 --> 00:01:49,479

in this case lost city type vents must

47

00:01:54,660 --> 00:01:51,520

be adapted to a low dissolved inorganic

48

00:01:57,660 --> 00:01:54,670

carbon co₂ poor and hydrogen rich

49

00:02:00,270 --> 00:01:57,670

environment so why is it why is it co₂

50

00:02:02,999 --> 00:02:00,280

poor well the reason is is that carbon

51
00:02:05,520 --> 00:02:03,009
speciate s-- as a function of pH so in

52
00:02:07,349 --> 00:02:05,530
this plot on the x axis is concentration

53
00:02:09,600 --> 00:02:07,359
of carbon the numbers don't mean much

54
00:02:13,770 --> 00:02:09,610
for this for this particular talk and on

55
00:02:16,380 --> 00:02:13,780
the x axis is pH so in regions of acidic

56
00:02:17,250 --> 00:02:16,390
fluids carbons preferentially speciate

57
00:02:19,559 --> 00:02:17,260
s-- into co2

58
00:02:21,210 --> 00:02:19,569
whereas in circle neutral pH carbon

59
00:02:23,370 --> 00:02:21,220
professionally speciate sin to bicarb

60
00:02:25,530 --> 00:02:23,380
and in alkaline pH covering

61
00:02:28,380 --> 00:02:25,540
preferentially speciate sin to carbonate

62
00:02:29,790 --> 00:02:28,390
so in alkaline environments that such

63
00:02:32,370 --> 00:02:29,800

that accompanied those of active

64

00:02:34,710 --> 00:02:32,380

serpentinization the co2 concentrations

65

00:02:37,080 --> 00:02:34,720

are really poor and is that important

66

00:02:40,590 --> 00:02:37,090

well limiting illustrate this in another

67

00:02:43,830 --> 00:02:40,600

plot here I plot hydrogen concentrations

68

00:02:46,530 --> 00:02:43,840

on the y axis and co2 concentrations on

69

00:02:47,670 --> 00:02:46,540

the x axis and these black squares here

70

00:02:49,920 --> 00:02:47,680

are kind of a collection from the

71

00:02:54,750 --> 00:02:49,930

literature of sites of methanol Genesis

72

00:02:56,490 --> 00:02:54,760

right rumen goats rice soils swamps the

73

00:03:00,240 --> 00:02:56,500

lake sediments just kind of a collection

74

00:03:02,460 --> 00:03:00,250

and they all plot down here high co2 low

75

00:03:04,020 --> 00:03:02,470

hydrogen where as sites of active sand

76

00:03:05,760 --> 00:03:04,030

potent ization again a collection from

77

00:03:07,980 --> 00:03:05,770

the literature chromo velocity or mine

78

00:03:10,470 --> 00:03:07,990

cedars and Tablelands and they all have

79

00:03:12,150 --> 00:03:10,480

high hydrogen Moore s and very low co2

80

00:03:14,820 --> 00:03:12,160

so all everything that we know about

81

00:03:18,090 --> 00:03:14,830

methanogenesis is done with bugs that we

82

00:03:19,500 --> 00:03:18,100

can sample easily and those are hydrogen

83

00:03:22,110 --> 00:03:19,510

limited whereas when we seek to

84

00:03:24,000 --> 00:03:22,120

understand life in in serpentinization

85

00:03:26,130 --> 00:03:24,010

environments while those are hydrogen

86

00:03:29,340 --> 00:03:26,140

limpid and that's important difference I

87

00:03:31,800 --> 00:03:29,350

also plot up here a hypothetical culture

88

00:03:33,930 --> 00:03:31,810

of methanol methanogens typically when

89

00:03:35,670 --> 00:03:33,940

we put them in test tubes we blast them

90

00:03:37,410 --> 00:03:35,680

with a lot of co₂ a lot of hydrogen so

91

00:03:39,710 --> 00:03:37,420

that they're happy so again what we know

92

00:03:41,880 --> 00:03:39,720

about metallic jeans comes from a

93

00:03:43,530 --> 00:03:41,890

physical chemical space that is not

94

00:03:45,750 --> 00:03:43,540

expected in serpentinization

95

00:03:47,850 --> 00:03:45,760

environments so then how do we assess

96

00:03:50,520 --> 00:03:47,860

the energetic the energetics available

97

00:03:52,860 --> 00:03:50,530

for these systems allow me a quick 30

98

00:03:54,330 --> 00:03:52,870

second bio energetic primer some of you

99

00:03:57,539 --> 00:03:54,340

may be astronomers in the room I don't

100

00:03:59,190 --> 00:03:57,549

know but imagine a bug as a light bulb

101
00:04:01,020 --> 00:03:59,200
on the sea floor and the reason why it

102
00:04:03,330 --> 00:04:01,030
shines is because it's connected to a

103
00:04:05,850 --> 00:04:03,340
battery a battery provides a voltage

104
00:04:07,470 --> 00:04:05,860
that enables the flow of charge carriers

105
00:04:09,390 --> 00:04:07,480
or a current the product of the voltage

106
00:04:11,820 --> 00:04:09,400
and the current is the power and in

107
00:04:13,770 --> 00:04:11,830
natural environments the analogy is such

108
00:04:15,390 --> 00:04:13,780
that the voltage is the Gibbs free

109
00:04:17,190 --> 00:04:15,400
energy that we can calculate from the

110
00:04:19,140 --> 00:04:17,200
local conditions and so it keeps free

111
00:04:20,880 --> 00:04:19,150
energies and energy made available by an

112
00:04:23,610 --> 00:04:20,890
environment for the bugs to do work

113
00:04:27,870 --> 00:04:23,620

right so if we plot the same sites as I

114

00:04:30,089 --> 00:04:27,880

showed earlier just was there Delta G so

115

00:04:32,310 --> 00:04:30,099

on the y-axis and the only axis is the

116

00:04:34,559 --> 00:04:32,320

is the Gibbs free energy here which is

117

00:04:36,089 --> 00:04:34,569

the negative of the affinity the early

118

00:04:37,529 --> 00:04:36,099

earlier this week there are many talks

119

00:04:39,089 --> 00:04:37,539

about the affinity is the same thing as

120

00:04:41,279 --> 00:04:39,099

it gives free energy just a sinus worked

121

00:04:43,919 --> 00:04:41,289

anything that's more negative than about

122

00:04:46,109 --> 00:04:43,929

-10 is considered energetically

123

00:04:48,149 --> 00:04:46,119

favorable right so in black again is our

124

00:04:50,809 --> 00:04:48,159

sites of classical methanogenesis all

125

00:04:53,429 --> 00:04:50,819

below minus 10 all very happy and

126

00:04:56,159 --> 00:04:53,439

quantifiably favorable for

127

00:04:57,749 --> 00:04:56,169

methanogenesis using this metric and the

128

00:04:59,850 --> 00:04:57,759

sites of active serpentinization

129

00:05:03,149 --> 00:04:59,860

are some of them are even more favorable

130

00:05:04,429 --> 00:05:03,159

for for using this metric for for

131

00:05:06,689 --> 00:05:04,439

methanogenesis

132

00:05:08,399 --> 00:05:06,699

but this is not the full story right you

133

00:05:10,199 --> 00:05:08,409

cannot describe the electrical

134

00:05:12,659 --> 00:05:10,209

properties of a light bulb with voltage

135

00:05:14,609 --> 00:05:12,669

alone you need to understand the current

136

00:05:16,290 --> 00:05:14,619

as well so the point of this

137

00:05:18,119 --> 00:05:16,300

presentation perhaps is to encourage all

138

00:05:20,309 --> 00:05:18,129

of you who think about energetics in

139

00:05:24,359 --> 00:05:20,319

these natural systems to go beyond delta

140

00:05:26,969 --> 00:05:24,369

g to to to assess whether or not an

141

00:05:30,209 --> 00:05:26,979

environment can host life so let me a

142

00:05:32,999 --> 00:05:30,219

hammer that one more time delta g is

143

00:05:36,689 --> 00:05:33,009

calculated from both values only right

144

00:05:38,129 --> 00:05:36,699

but cells consume carbon and hydrogen so

145

00:05:39,209 --> 00:05:38,139

the concentration inside the cell is

146

00:05:40,559 --> 00:05:39,219

different than the BOK therefore the

147

00:05:42,749 --> 00:05:40,569

delta g inside the cell is also

148

00:05:44,850 --> 00:05:42,759

different but a cell is complicated

149

00:05:46,320 --> 00:05:44,860

right how do you take into account what

150

00:05:47,939 --> 00:05:46,330

is the physics that brings the material

151

00:05:49,019 --> 00:05:47,949

inside the cell what about the effects

152

00:05:50,790 --> 00:05:49,029

of a cell membrane what about the

153

00:05:52,980 --> 00:05:50,800

enzymatic rates that convert the carbon

154

00:05:54,329 --> 00:05:52,990

from co₂ to methane all those things are

155

00:05:59,179 --> 00:05:54,339

important that so that's where systems

156

00:06:01,499 --> 00:05:59,189

biology comes in handy so we've used a a

157

00:06:03,629 --> 00:06:01,509

single cell reactive transfer model

158

00:06:06,719 --> 00:06:03,639

developed by outrun and Haller in 2009

159

00:06:08,489 --> 00:06:06,729

that takes diffusion as the as the mass

160

00:06:10,199 --> 00:06:08,499

transport mechanism because we're

161

00:06:12,269 --> 00:06:10,209

working with simple molecules like co₂

162

00:06:14,309 --> 00:06:12,279

and hydrogen they just diffused through

163

00:06:16,139 --> 00:06:14,319

the through the membrane the reaction

164

00:06:17,699 --> 00:06:16,149

rates are simulated using Monod kinetics

165

00:06:20,399 --> 00:06:17,709

that's the plot on the right I'll talk

166

00:06:22,350 --> 00:06:20,409

about in a sec and we can take into

167

00:06:24,779 --> 00:06:22,360

account the the membrane matter is kind

168

00:06:27,329 --> 00:06:24,789

of slows down the diffusion process so

169

00:06:28,980 --> 00:06:27,339

the the the the reaction rates is kind

170

00:06:31,230 --> 00:06:28,990

of the Monod kinetics reaction here you

171

00:06:33,689 --> 00:06:31,240

can see that enzymes saturate on the x

172

00:06:36,689 --> 00:06:33,699

axis is the concentration on the y axis

173

00:06:39,089 --> 00:06:36,699

is the rates this is the same plots to

174

00:06:40,859 --> 00:06:39,099

illustrate that is only so much pizza

175

00:06:42,580 --> 00:06:40,869

you can feed graduate students before

176

00:06:46,150 --> 00:06:42,590

they saturate right

177

00:06:48,100 --> 00:06:46,160

so on the x-axis is is a pizza on the

178

00:06:50,440 --> 00:06:48,110

y-axis here is that rate at which they

179

00:06:52,810 --> 00:06:50,450

can eat it the km here is the kinetic

180

00:06:55,360 --> 00:06:52,820

parameter also known as the the budget

181

00:06:56,890 --> 00:06:55,370

of the department so from what they see

182

00:06:59,350 --> 00:06:56,900

I'm taking this analogy way too far

183

00:07:01,300 --> 00:06:59,360

sorry but anyways the the curve the grad

184

00:07:03,100 --> 00:07:01,310

student and the and the met an engine is

185

00:07:07,500 --> 00:07:03,110

the same right just the the kinetic

186

00:07:10,930 --> 00:07:07,510

parameters are different for its reasons

187

00:07:13,450 --> 00:07:10,940

so if you take this this this is

188

00:07:14,620 --> 00:07:13,460

enzymatic rates that's the current right

189

00:07:16,750 --> 00:07:14,630

the amount of material going into the

190

00:07:19,330 --> 00:07:16,760

cell per unit time so multiply that by

191

00:07:21,300 --> 00:07:19,340

the Delta G that's inside the cell you

192

00:07:23,980 --> 00:07:21,310

get a power so instead of looking at

193

00:07:26,170 --> 00:07:23,990

Delta G from the bulk environment alone

194

00:07:28,900 --> 00:07:26,180

you can look at energetics from a 2deep

195

00:07:31,090 --> 00:07:28,910

2deep perspective on the x-axis is the

196

00:07:33,280 --> 00:07:31,100

same as before that delta g then on the

197

00:07:35,290 --> 00:07:33,290

y-axis is that power I was telling you

198

00:07:36,970 --> 00:07:35,300

about and this changes the story a

199

00:07:38,680 --> 00:07:36,980

little bit right what you can see here

200

00:07:41,470 --> 00:07:38,690

is all the sites of classical

201
00:07:44,350 --> 00:07:41,480
methanogenesis are on the right of a

202
00:07:46,750 --> 00:07:44,360
boundary and on the sites of actives

203
00:07:49,450 --> 00:07:46,760
important ization on the left and this

204
00:07:52,050 --> 00:07:49,460
boundary here is is a measurement of

205
00:07:54,670 --> 00:07:52,060
minimum flux to enable biological

206
00:07:57,190 --> 00:07:54,680
turnover and calculate it completely

207
00:08:00,430 --> 00:07:57,200
independently from sulfate reducers in

208
00:08:04,030 --> 00:08:00,440
the Aarhus Bay from in up holler and

209
00:08:05,320 --> 00:08:04,040
your consent 2013 so this is a very

210
00:08:06,820 --> 00:08:05,330
different conclusion than looking at

211
00:08:08,620 --> 00:08:06,830
just delta g alone right looking at

212
00:08:10,750 --> 00:08:08,630
delta g alone sites of actives and

213
00:08:13,450 --> 00:08:10,760

fertilization were awesome for life

214

00:08:16,000 --> 00:08:13,460

using this perspective you don't expect

215

00:08:19,480 --> 00:08:16,010

methanogens to be to be present in in

216

00:08:21,010 --> 00:08:19,490

sites of active synchronization so so

217

00:08:22,660 --> 00:08:21,020

how do you reconcile that so there's a

218

00:08:25,420 --> 00:08:22,670

great talk earlier this apps icon by

219

00:08:27,430 --> 00:08:25,430

Emily Krause who shows that there is

220

00:08:28,180 --> 00:08:27,440

such methanogens so so how do you

221

00:08:29,890 --> 00:08:28,190

reconcile the two

222

00:08:32,710 --> 00:08:29,900

so before we try and think about that

223

00:08:36,220 --> 00:08:32,720

let me just make two points regarding

224

00:08:39,780 --> 00:08:36,230

the Gibbs free energy first hi hydrogen

225

00:08:42,700 --> 00:08:39,790

in supermans in serpentine izing systems

226

00:08:44,860 --> 00:08:42,710

can kind of fool you right today's they

227

00:08:47,380 --> 00:08:44,870

are from that perspective alone the

228

00:08:48,730 --> 00:08:47,390

these sites are energetically favorable

229

00:08:51,700 --> 00:08:48,740

however when thinking about the power

230

00:08:53,470 --> 00:08:51,710

requirements of a cell then the the

231

00:08:55,720 --> 00:08:53,480

energy use scenario is

232

00:08:57,519 --> 00:08:55,730

different so how did how do we then

233

00:08:59,590 --> 00:08:57,529

reconcile the results with observation

234

00:09:01,269 --> 00:08:59,600

of meth engines in serpent rising

235

00:09:02,710 --> 00:09:01,279

systems or he comes a disadvantage of

236

00:09:03,939 --> 00:09:02,720

giving a Friday talk is that you have to

237

00:09:05,860 --> 00:09:03,949

accumulate everything that comes during

238

00:09:16,389 --> 00:09:05,870

the week and it can alter your

239

00:09:18,160 --> 00:09:16,399

conclusions a little bit so yeah so so

240

00:09:20,500 --> 00:09:18,170

so to reconcile this we can use the same

241

00:09:22,170 --> 00:09:20,510

modeling approach that we that I showed

242

00:09:26,470 --> 00:09:22,180

you earlier

243

00:09:28,269 --> 00:09:26,480

what if methanogens had enzymes that

244

00:09:30,579 --> 00:09:28,279

were on the on the on the membranes

245

00:09:32,170 --> 00:09:30,589

right instead of diffusing the material

246

00:09:33,970 --> 00:09:32,180

inside the cell they would had those

247

00:09:35,560 --> 00:09:33,980

enzymes that would translate the co2 to

248

00:09:37,750 --> 00:09:35,570

methane on the cell on the cell itself

249

00:09:40,540 --> 00:09:37,760

and preliminary calculations showed that

250

00:09:42,460 --> 00:09:40,550

that improves things about 20% right

251
00:09:44,860 --> 00:09:42,470
which is not enough to talk to to cross

252
00:09:48,430 --> 00:09:44,870
that threshold alternatively the cells

253
00:09:50,500 --> 00:09:48,440
could be using bicarbonates that could

254
00:09:52,000 --> 00:09:50,510
enter the cell through through porins

255
00:09:53,860 --> 00:09:52,010
through ion channels bicarbonate is

256
00:09:56,350 --> 00:09:53,870
charged so I cannot just diffuse inside

257
00:09:59,019 --> 00:09:56,360
the cell so those pH inside the cell is

258
00:10:01,269 --> 00:09:59,029
neutral roughly so the speciate the by

259
00:10:03,100 --> 00:10:01,279
covenant would speciate back to co2 so

260
00:10:05,259 --> 00:10:03,110
that could be an enhancement of co2

261
00:10:06,400 --> 00:10:05,269
inside the cell but once you have co2

262
00:10:08,530 --> 00:10:06,410
inside the cell that's a higher

263
00:10:10,960 --> 00:10:08,540

concentration and outside it diffuses

264

00:10:13,180 --> 00:10:10,970

right back out and not useful for for

265

00:10:14,500 --> 00:10:13,190

methanogenesis so that doesn't seem to

266

00:10:16,870 --> 00:10:14,510

work either we're exploring other

267

00:10:18,670 --> 00:10:16,880

solutions like formate and acetate and

268

00:10:20,980 --> 00:10:18,680

even co2 there was a poster by Jackie

269

00:10:23,400 --> 00:10:20,990

cordial using meta genomics where she

270

00:10:26,620 --> 00:10:23,410

found her own to butcher her science

271

00:10:28,300 --> 00:10:26,630

carbon monoxide dehydrogenase in hermit

272

00:10:32,800 --> 00:10:28,310

metagenomes so maybe that's that's an

273

00:10:35,439 --> 00:10:32,810

avenue as well or there's this kinetic

274

00:10:37,090 --> 00:10:35,449

parameter that might be different right

275

00:10:39,280 --> 00:10:37,100

in the kinetic parameters was the one is

276

00:10:41,079 --> 00:10:39,290

the grad student plots the one we chose

277

00:10:44,230 --> 00:10:41,089

for the model is from the literature and

278

00:10:46,360 --> 00:10:44,240

the literature value is found from sites

279

00:10:49,300 --> 00:10:46,370

of active metallurgist metal meth an

280

00:10:50,920 --> 00:10:49,310

agenda that we know today but remember

281

00:10:52,900 --> 00:10:50,930

this plot I showed in the beginning was

282

00:10:55,720 --> 00:10:52,910

hydrogen on the y axis and co2 on the x

283

00:10:57,360 --> 00:10:55,730

axis here I plot that km value that

284

00:11:00,879 --> 00:10:57,370

kinetic parameter for co2 and hydrogen

285

00:11:02,740 --> 00:11:00,889

and the equation for power is in fact

286

00:11:06,429 --> 00:11:02,750

inversely proportional to the sum of

287

00:11:07,380 --> 00:11:06,439

that km plus co2 now for sites of active

288

00:11:10,570 --> 00:11:07,390

methanogenesis

289

00:11:12,910 --> 00:11:10,580

this ratio is controlled by the

290

00:11:14,440 --> 00:11:12,920

concentration of co₂ alone right you

291

00:11:16,660 --> 00:11:14,450

could increase the power by decreasing

292

00:11:18,910 --> 00:11:16,670

that km but it won't do much because

293

00:11:22,360 --> 00:11:18,920

that ratio is set by the concentration

294

00:11:24,340 --> 00:11:22,370

of co₂ for sites of kind of classical

295

00:11:26,170 --> 00:11:24,350

methanogenesis however that's not the

296

00:11:28,120 --> 00:11:26,180

case for sites of active

297

00:11:30,460 --> 00:11:28,130

serpentinization right that ratio is

298

00:11:33,340 --> 00:11:30,470

actually controlled by the km value

299

00:11:35,680 --> 00:11:33,350

because the co₂ is so small so you can

300

00:11:39,130 --> 00:11:35,690

perhaps think that the bugs have figured

301

00:11:41,200 --> 00:11:39,140

out how to drop their their km value by

302

00:11:42,640 --> 00:11:41,210

say an order of magnitude because from

303

00:11:45,820 --> 00:11:42,650

that ratio that would increase the power

304

00:11:47,590 --> 00:11:45,830

by an order of magnitude and so I I read

305

00:11:49,630 --> 00:11:47,600

it those redid the same calculations

306

00:11:51,670 --> 00:11:49,640

with Delta G on the y-axis and power on

307

00:11:54,310 --> 00:11:51,680

the x-axis here that's that same limit

308

00:11:56,260 --> 00:11:54,320

from Alperin and Jurgen sin 2013 but

309

00:11:58,360 --> 00:11:56,270

which is different kinetic parameter and

310

00:12:00,490 --> 00:11:58,370

you can see that some of the sites of of

311

00:12:02,260 --> 00:12:00,500

activists urbanization do become

312

00:12:04,120 --> 00:12:02,270

habitable from this perspective right we

313

00:12:07,180 --> 00:12:04,130

have almost all of them except for two

314

00:12:09,430 --> 00:12:07,190

from LA City one from Amman and so we're

315

00:12:11,230 --> 00:12:09,440

getting very close to that threshold so

316

00:12:13,570 --> 00:12:11,240

perhaps that's an avenue right bugs have

317

00:12:15,520 --> 00:12:13,580

evolved to have a different kinetic

318

00:12:17,410 --> 00:12:15,530

parameter that we do not observe in

319

00:12:18,940 --> 00:12:17,420

cultured experiments because we culture

320

00:12:23,230 --> 00:12:18,950

from sites that we can actively sample

321

00:12:26,560 --> 00:12:23,240

them so this is kind of the two plots so

322

00:12:29,200 --> 00:12:26,570

you can see with the km from the

323

00:12:31,360 --> 00:12:29,210

literature versus kind of playing with

324

00:12:33,970 --> 00:12:31,370

playing with the the that km values to

325

00:12:35,970 --> 00:12:33,980

shift a little bit that perspective so

326

00:12:38,110 --> 00:12:35,980

that's it I don't think there's any

327

00:12:40,780 --> 00:12:38,120

conclusions we can do at this point but

328

00:12:42,640 --> 00:12:40,790

the energetics of an environments that

329

00:12:43,270 --> 00:12:42,650

can host or patent ization that can host

330

00:12:45,130 --> 00:12:43,280

methanogens

331

00:12:47,260 --> 00:12:45,140

through personalization is just I think

332

00:12:50,010 --> 00:12:47,270

more tricky than has been traditionally

333

00:12:53,350 --> 00:12:50,020

thought of thank you

334

00:12:53,360 --> 00:12:59,650

time for a question for sunshine

335

00:13:21,050 --> 00:13:20,060

pressure I don't know I'm a it's a good

336

00:13:24,620 --> 00:13:21,060

question so the question is how does

337

00:13:28,040 --> 00:13:24,630

pressure affect the the enzyme kinetics

338

00:13:29,870 --> 00:13:28,050

I don't I've not seen a study that took

339

00:13:32,240 --> 00:13:29,880

spent methanogens and puts them under

340

00:13:33,800 --> 00:13:32,250

high pressure or net and sees what the

341

00:13:35,449 --> 00:13:33,810

rates are different compared to

342

00:13:37,040 --> 00:13:35,459

traditional hemostats I think there'll

343

00:13:52,370 --> 00:13:37,050

be a really cool experiment harder but

344

00:13:53,720 --> 00:13:52,380

really cool experiment yeah I don't but

345

00:13:59,829 --> 00:13:53,730

that's in the literature I don't have

346

00:14:04,550 --> 00:14:01,449

hi Sean

347

00:14:06,440 --> 00:14:04,560

hey thanks for the great talk I had a

348

00:14:08,060 --> 00:14:06,450

question about where the km value comes

349

00:14:09,980 --> 00:14:08,070

whether or not it it's from a mat

350

00:14:12,650 --> 00:14:09,990

antigen with cytochromes or one without

351

00:14:14,000 --> 00:14:12,660

cytochromes and that that's a really

352

00:14:16,160 --> 00:14:14,010

simple question you can answer them a

353

00:14:18,530 --> 00:14:16,170

word but the other point I wanted to

354

00:14:20,870 --> 00:14:18,540

raise was I wonder how your model

355

00:14:22,880 --> 00:14:20,880

results compare against the data with

356

00:14:25,370 --> 00:14:22,890

hydrogen concentration thresholds

357

00:14:28,400 --> 00:14:25,380

because it used to be thought that the

358

00:14:30,050 --> 00:14:28,410

km was the control of how much what's

359

00:14:32,060 --> 00:14:30,060

the lowest concentration of hydrogen

360

00:14:34,519 --> 00:14:32,070

solution these methanogens could grow on

361

00:14:37,250 --> 00:14:34,529

but later on it kind of seems like it

362

00:14:38,810 --> 00:14:37,260

panned out that it turns big it boils

363

00:14:40,760 --> 00:14:38,820

down to the bioenergetics of how much

364

00:14:43,310 --> 00:14:40,770

energy it takes to pump a single ion

365

00:14:46,130 --> 00:14:43,320

across the membrane three chemiosmosis

366

00:14:48,260 --> 00:14:46,140

right so I was wondering have you mapped

367

00:14:50,180 --> 00:14:48,270

that on to the hydrogen question two and

368

00:14:52,550 --> 00:14:50,190

if that could help you understand your

369

00:14:58,639 --> 00:14:52,560

results so that that threshold is that

370

00:15:01,160 --> 00:14:58,649

minus 10 kilojoules so I think what

371

00:15:03,650 --> 00:15:01,170

we've seen in environments that that

372

00:15:05,110 --> 00:15:03,660

energetic value is much much much more

373

00:15:06,759 --> 00:15:05,120

negative than that

374

00:15:09,310 --> 00:15:06,769

I guess I'm not understanding your

375

00:15:11,319 --> 00:15:09,320

question very well but we can talk about

376

00:15:13,449 --> 00:15:11,329

later psychic and how about the km

377

00:15:14,980 --> 00:15:13,459

whereas the km from is it from scientist

378

00:15:17,019 --> 00:15:14,990

a scientist at a chrome containing

379

00:15:19,750 --> 00:15:17,029

methanogens likes our sonali's or is it

380

00:15:20,800 --> 00:15:19,760

from like a mechanic a CODIS I don't

381

00:15:23,019 --> 00:15:20,810

remember okay

382

00:15:49,410 --> 00:15:23,029

but I have the paper if it'll check with

383

00:15:54,570 --> 00:15:52,350

thanks sorry thanks Sean let's take