

2 ASTROBIOLOGY
0 GRADUATE
1 CONFERENCE
7



CHARLOTTESVILLE, VA

1
00:00:00,790 --> 00:00:08,560

[Music]

2
00:00:13,970 --> 00:00:11,000

hello everyone so I'm going to sort of

3
00:00:15,530 --> 00:00:13,980

completely switch gears so I'm a

4
00:00:18,080 --> 00:00:15,540

master's student at Johns Hopkins

5
00:00:20,810 --> 00:00:18,090

studying bio informatics and I also work

6
00:00:23,840 --> 00:00:20,820

at Jet Propulsion lab under the

7
00:00:24,980 --> 00:00:23,850

planetary protection group and today I'm

8
00:00:28,130 --> 00:00:24,990

sort of not going to talk about either

9
00:00:30,620 --> 00:00:28,140

those things so we're going to talk

10
00:00:32,840 --> 00:00:30,630

about the organic detection in evaporite

11
00:00:37,729 --> 00:00:32,850

minerals and what that tells us about

12
00:00:40,340 --> 00:00:37,739

our search for biosignatures on Mars so

13
00:00:43,459 --> 00:00:40,350

sort of the purpose to track the

14

00:00:45,410 --> 00:00:43,469

microbiological changes that occur when

15

00:00:48,470 --> 00:00:45,420

going from an active biological system

16

00:00:52,119 --> 00:00:48,480

into these evaporite minerals prior to

17

00:00:55,430 --> 00:00:52,129

during and after evaporite of formation

18

00:00:58,010 --> 00:00:55,440

so the methods we employed so we extract

19

00:01:00,410 --> 00:00:58,020

the DNA from multiple samples and

20

00:01:03,799 --> 00:01:00,420

developed in-house validation techniques

21

00:01:06,800 --> 00:01:03,809

to confirm the extraction from hyper

22

00:01:08,780 --> 00:01:06,810

saline fluids as some of you may know

23

00:01:10,820 --> 00:01:08,790

that this might be difficult due to

24

00:01:13,700 --> 00:01:10,830

inhibitors that are present within the

25

00:01:16,370 --> 00:01:13,710

fluids and the minerals we also utilized

26
00:01:18,830 --> 00:01:16,380
Rahman datasets to compare the active

27
00:01:20,120 --> 00:01:18,840
biological information into the

28
00:01:23,060 --> 00:01:20,130
evaporite minerals and what we're

29
00:01:24,499 --> 00:01:23,070
detecting they're sort of the goals we

30
00:01:27,800 --> 00:01:24,509
want to quantify the preservation

31
00:01:30,109 --> 00:01:27,810
potential when going from an active

32
00:01:32,420 --> 00:01:30,119
system into evaporite minerals which may

33
00:01:35,120 --> 00:01:32,430
be Sol which may support active

34
00:01:37,910 --> 00:01:35,130
biological life or may sort of form

35
00:01:39,920 --> 00:01:37,920
dormant versions of the microorganisms

36
00:01:42,319 --> 00:01:39,930
that are present we also wanted to

37
00:01:44,300 --> 00:01:42,329
compare the sensitivity of these bio

38
00:01:48,410 --> 00:01:44,310

signatures and comparing multiple

39

00:01:49,880 --> 00:01:48,420

detection techniques within modern

40

00:01:54,200 --> 00:01:49,890

evaporites and what that looks like

41

00:01:55,399 --> 00:01:54,210

across a larger time scale so the three

42

00:01:57,440 --> 00:01:55,409

main questions that we looked at what

43

00:01:59,749 --> 00:01:57,450

would be the threshold of detection for

44

00:02:01,280 --> 00:01:59,759

both the bio signatures what the

45

00:02:03,440 --> 00:02:01,290

preservation looks like and what that

46

00:02:05,899 --> 00:02:03,450

looks like over a larger geological time

47

00:02:08,419 --> 00:02:05,909

scale so how much biology would you need

48

00:02:10,910 --> 00:02:08,429

in the active system to constitute a

49

00:02:13,680 --> 00:02:10,920

viable and detectable signal within the

50

00:02:15,810 --> 00:02:13,690

evaporite minerals sort of what what

51
00:02:19,170 --> 00:02:15,820
can get preserved from the active system

52
00:02:21,060 --> 00:02:19,180
and if there's any selection as to what

53
00:02:22,500 --> 00:02:21,070
is being selected and what is being

54
00:02:26,400 --> 00:02:22,510
preserved within the evaporite minerals

55
00:02:27,960 --> 00:02:26,410
for a longer time scale so the

56
00:02:30,540 --> 00:02:27,970
motivation behind this study this is

57
00:02:33,240 --> 00:02:30,550
chrim data from the Mars Reconnaissance

58
00:02:36,090 --> 00:02:33,250
Orbiter which is an orbiter on Mars that

59
00:02:38,610 --> 00:02:36,100
got there in 2006 so as you can see

60
00:02:41,370 --> 00:02:38,620
we've detected phyllosilicates silica

61
00:02:42,960 --> 00:02:41,380
chlorides carbonates and sulfates which

62
00:02:44,580 --> 00:02:42,970
is what we're what which is what I'm

63
00:02:49,050 --> 00:02:44,590

going to talk about so particularly

64

00:02:51,120 --> 00:02:49,060

gypsum and halite so this is the

65

00:02:52,800 --> 00:02:51,130

analogue site that we used to study

66

00:02:55,650 --> 00:02:52,810

these evaporite minerals to the north

67

00:02:58,260 --> 00:02:55,660

arm of the Great Salt Lake in Utah this

68

00:03:01,470 --> 00:02:58,270

is an active system supports a variety

69

00:03:03,240 --> 00:03:01,480

of microbial organisms and it is cut off

70

00:03:07,110 --> 00:03:03,250

from the south arm so it is a closed

71

00:03:09,120 --> 00:03:07,120

system and sort of the analogous site on

72

00:03:11,910 --> 00:03:09,130

Mars would be the Jazira crater where

73

00:03:13,460 --> 00:03:11,920

we've detected the presence of clays and

74

00:03:16,260 --> 00:03:13,470

sulfates

75

00:03:18,300 --> 00:03:16,270

again another analogous environment

76
00:03:20,010 --> 00:03:18,310
between what we studied and Mars so the

77
00:03:22,710 --> 00:03:20,020
gypsum crystals that we looked at and

78
00:03:24,900 --> 00:03:22,720
sort of the sulfate veins which are

79
00:03:27,180 --> 00:03:24,910
hydrated minerals that are present

80
00:03:32,640 --> 00:03:27,190
within Gale Crater on Mars and this is

81
00:03:35,190 --> 00:03:32,650
an image from MSL so sort of going

82
00:03:37,560 --> 00:03:35,200
through the various samples that we

83
00:03:40,550 --> 00:03:37,570
looked at so we focused on the hey light

84
00:03:42,930 --> 00:03:40,560
hopper crystals that are found here and

85
00:03:45,210 --> 00:03:42,940
particularly within these crystals we

86
00:03:47,699 --> 00:03:45,220
wanted to focus on the fluid inclusions

87
00:03:50,040 --> 00:03:47,709
within them so these may serve as sort

88
00:03:52,290 --> 00:03:50,050

of micro environments within the crystal

89

00:03:54,750 --> 00:03:52,300

that may support maybe even active

90

00:03:58,440 --> 00:03:54,760

metabolic some of these organisms that

91

00:04:00,060 --> 00:03:58,450

are being preserved here on the bottom

92

00:04:02,310 --> 00:04:00,070

these are the hey light terraces that

93

00:04:05,130 --> 00:04:02,320

were sampled so on the top you can see a

94

00:04:06,720 --> 00:04:05,140

much clearer white in comparison to the

95

00:04:09,390 --> 00:04:06,730

bottom that has sort of a pinkish color

96

00:04:11,760 --> 00:04:09,400

to it so the top we believe I mean you

97

00:04:13,920 --> 00:04:11,770

have the same sort of biology that's

98

00:04:16,349 --> 00:04:13,930

present within these two however the top

99

00:04:19,409 --> 00:04:16,359

is being irradiated by UV radiation and

100

00:04:22,020 --> 00:04:19,419

and we believe that that pigmentation

101
00:04:23,250 --> 00:04:22,030
loss is due to that although you can't

102
00:04:27,330 --> 00:04:23,260
see it in this image but underneath

103
00:04:27,930 --> 00:04:27,340
these pink crystal or the pink hey light

104
00:04:30,420 --> 00:04:27,940
Terrace

105
00:04:32,850 --> 00:04:30,430
there is sort of a pool of the lake

106
00:04:34,680 --> 00:04:32,860
water that is providing continual inputs

107
00:04:37,080 --> 00:04:34,690
into the formation of these evaporites

108
00:04:38,730 --> 00:04:37,090
so sort of looking at the microbiology

109
00:04:41,340 --> 00:04:38,740
that's present within the liquid and

110
00:04:44,700 --> 00:04:41,350
what we can extract from the evaporites

111
00:04:47,160 --> 00:04:44,710
can tell us what is being preserved the

112
00:04:50,550 --> 00:04:47,170
gypsum crystals on the right we also

113
00:04:52,350 --> 00:04:50,560

extracted DNA from these and again

114

00:04:54,270 --> 00:04:52,360

similar to the hey light hopper crystals

115

00:04:56,730 --> 00:04:54,280

we wanted to understand whether those

116

00:04:59,820 --> 00:04:56,740

clays which are being entombed within

117

00:05:02,850 --> 00:04:59,830

the gypsum crystals again provide a sort

118

00:05:04,770 --> 00:05:02,860

of safe haven for the microbial life

119

00:05:08,130 --> 00:05:04,780

that's being preserved within these as

120

00:05:10,230 --> 00:05:08,140

well as the potential bio signatures and

121

00:05:11,970 --> 00:05:10,240

then comparing that with in the

122

00:05:13,920 --> 00:05:11,980

unfiltered lake water as well as the

123

00:05:18,810 --> 00:05:13,930

environmental controls so the unfiltered

124

00:05:20,610 --> 00:05:18,820

lake water is home to active life and so

125

00:05:22,110 --> 00:05:20,620

looking at the sort of diversity and

126

00:05:25,500 --> 00:05:22,120

abundance that's present there in

127

00:05:27,680 --> 00:05:25,510

comparison to the crystals will allow us

128

00:05:30,420 --> 00:05:27,690

to understand what that preservation

129

00:05:34,080 --> 00:05:30,430

potential looks like the environmental

130

00:05:37,140 --> 00:05:34,090

controls sort of served as a baseline to

131

00:05:39,030 --> 00:05:37,150

understand whether or not any any of the

132

00:05:41,700 --> 00:05:39,040

surrounding sediment that's within the

133

00:05:45,300 --> 00:05:41,710

vicinity of these crystals had any

134

00:05:49,320 --> 00:05:45,310

inputs in terms of the microbial life

135

00:05:51,470 --> 00:05:49,330

that we're detecting so this is an

136

00:05:54,120 --> 00:05:51,480

overall map of sort of some of the most

137

00:05:58,170 --> 00:05:54,130

relevant biomolecules that we've looked

138

00:06:00,420 --> 00:05:58,180

at so DNA of course provides the most

139

00:06:02,040 --> 00:06:00,430

relevant information you can extract out

140

00:06:04,950 --> 00:06:02,050

the resistances that are present with

141

00:06:07,170 --> 00:06:04,960

indeed within these microorganisms their

142

00:06:09,500 --> 00:06:07,180

metabolic pathways you get down to

143

00:06:12,090 --> 00:06:09,510

species even strain level information

144

00:06:14,130 --> 00:06:12,100

however it is fairly a short-lived

145

00:06:16,470 --> 00:06:14,140

molecule in comparison to some of these

146

00:06:21,530 --> 00:06:16,480

others proteins which would be the

147

00:06:24,240 --> 00:06:21,540

active workers of the cell although

148

00:06:26,550 --> 00:06:24,250

those are that they do provide relevant

149

00:06:28,260 --> 00:06:26,560

information it is quite difficult to

150

00:06:30,810 --> 00:06:28,270

extract them and sort of relate them

151
00:06:32,960 --> 00:06:30,820
back to what species they came from

152
00:06:35,730 --> 00:06:32,970
within a mixed environmental sample

153
00:06:39,210 --> 00:06:35,740
similar to lipids where you have that

154
00:06:41,700 --> 00:06:39,220
limitation however these are viable over

155
00:06:43,980 --> 00:06:41,710
a larger geological time scale

156
00:06:45,540 --> 00:06:43,990
and then the total organic carbon which

157
00:06:48,720 --> 00:06:45,550
is the longest-lived and sort of

158
00:06:51,620 --> 00:06:48,730
comparing that as a robust bio signature

159
00:06:57,390 --> 00:06:51,630
back to DNA which would be our more

160
00:07:00,270 --> 00:06:57,400
relevant and highest resolution this is

161
00:07:02,430 --> 00:07:00,280
some of the preliminary data so we did

162
00:07:04,710 --> 00:07:02,440
extract DNA from these samples and we

163
00:07:06,450 --> 00:07:04,720

have sent them for sequencing to look at

164

00:07:09,930 --> 00:07:06,460

sort of the microbiome that's present

165

00:07:13,590 --> 00:07:09,940

across but we were able to extract DNA

166

00:07:16,230 --> 00:07:13,600

from all the samples so one thing to

167

00:07:18,330 --> 00:07:16,240

note is that this gypsum both the clay

168

00:07:21,270 --> 00:07:18,340

and non clay so we were able to target

169

00:07:23,850 --> 00:07:21,280

and take a core of just the clay and

170

00:07:25,980 --> 00:07:23,860

compare that back to the gypsum portions

171

00:07:30,300 --> 00:07:25,990

that didn't have that sediment entombed

172

00:07:31,890 --> 00:07:30,310

within them they do have much more DNA

173

00:07:34,530 --> 00:07:31,900

in comparison to some of these other

174

00:07:37,590 --> 00:07:34,540

samples including the active system and

175

00:07:41,070 --> 00:07:37,600

this is normalized down to a per gram or

176
00:07:43,740 --> 00:07:41,080
per ml of the material that we extracted

177
00:07:46,170 --> 00:07:43,750
from so although we know there's life

178
00:07:50,630 --> 00:07:46,180
here this is sort of a much more

179
00:07:53,010 --> 00:07:50,640
concentrated version of that lake water

180
00:07:56,250 --> 00:07:53,020
when you compare that to the sediment

181
00:07:58,290 --> 00:07:56,260
that's present the sediment is much more

182
00:08:01,440 --> 00:07:58,300
abundant in microbial life and and that

183
00:08:05,360 --> 00:08:01,450
makes sense because soil houses a great

184
00:08:07,410 --> 00:08:05,370
diversity of microbes and so

185
00:08:09,690 --> 00:08:07,420
understanding the microbial abundance

186
00:08:12,300 --> 00:08:09,700
present here we are able to track and

187
00:08:14,400 --> 00:08:12,310
parse out whether these had any inputs

188
00:08:17,630 --> 00:08:14,410

into the formation of the minerals and

189

00:08:20,900 --> 00:08:17,640

whether there's any crosstalk across

190

00:08:24,150 --> 00:08:20,910

this sort of the merged data of our

191

00:08:25,980 --> 00:08:24,160

various sample categories so we did

192

00:08:28,590 --> 00:08:25,990

sample multiple sites and replicates

193

00:08:30,780 --> 00:08:28,600

within those sites so you are again able

194

00:08:32,580 --> 00:08:30,790

to see that the lake water in comparison

195

00:08:35,520 --> 00:08:32,590

to the gypsum gypsum we're able to get

196

00:08:39,080 --> 00:08:35,530

much more DNA and environmental controls

197

00:08:42,660 --> 00:08:39,090

are still way above the evaporites

198

00:08:46,140 --> 00:08:42,670

system of the preliminary raman data we

199

00:08:48,810 --> 00:08:46,150

looked at so the main thing to note here

200

00:08:51,660 --> 00:08:48,820

is that the reference halo bacteria that

201
00:08:54,690 --> 00:08:51,670
we used this was a pure culture we did

202
00:08:55,260 --> 00:08:54,700
get similar peaks within that in

203
00:08:57,540 --> 00:08:55,270
comparison

204
00:08:59,640 --> 00:08:57,550
to the mixed environmental samples which

205
00:09:02,060 --> 00:08:59,650
tells us whatever we're detecting is

206
00:09:04,800 --> 00:09:02,070
sort of ubiquitously found across

207
00:09:06,990 --> 00:09:04,810
various different species because these

208
00:09:09,000 --> 00:09:07,000
may have multiple different species and

209
00:09:11,040 --> 00:09:09,010
this is a pure culture and we sort of

210
00:09:13,770 --> 00:09:11,050
trace that back to beta-carotene which

211
00:09:15,890 --> 00:09:13,780
was mentioned as something that comes up

212
00:09:18,290 --> 00:09:15,900
within Rahman data it's a carotenoid

213
00:09:24,120 --> 00:09:18,300

that some of these extreme affiliate

214

00:09:26,610 --> 00:09:24,130

organisms produce so in conclusion these

215

00:09:29,700 --> 00:09:26,620

evaporite minerals halite and gypsum do

216

00:09:31,920 --> 00:09:29,710

absolutely retain and preserve some of

217

00:09:36,990 --> 00:09:31,930

the biological material that's present

218

00:09:38,940 --> 00:09:37,000

within the lake system and in particular

219

00:09:41,040 --> 00:09:38,950

we wanted to focus on the fluid

220

00:09:43,860 --> 00:09:41,050

inclusions within the halite and the

221

00:09:47,130 --> 00:09:43,870

clay within the gypsum to see whether or

222

00:09:50,820 --> 00:09:47,140

not those have any selection as to what

223

00:09:53,840 --> 00:09:50,830

is being preserved within them on the

224

00:09:55,890 --> 00:09:53,850

right you see an image of using an FTIR

225

00:09:58,290 --> 00:09:55,900

spectrometer and this sort of the heat

226

00:10:00,780 --> 00:09:58,300

map that's overlaid onto the gypsum

227

00:10:02,190 --> 00:10:00,790

fluid inclusion which is here and this

228

00:10:05,250 --> 00:10:02,200

is sort of what the clay looks like

229

00:10:07,200 --> 00:10:05,260

that's entombed within the gypsum and so

230

00:10:09,420 --> 00:10:07,210

in the red here we're able to pinpoint

231

00:10:11,250 --> 00:10:09,430

the presence of the beta-carotene within

232

00:10:15,900 --> 00:10:11,260

that and start everything radiating

233

00:10:17,490 --> 00:10:15,910

away from the beta-carotene the so the

234

00:10:19,410 --> 00:10:17,500

raman signature peaks from the halo

235

00:10:21,510 --> 00:10:19,420

bacteria in comparison to the mixed

236

00:10:25,290 --> 00:10:21,520

environmental samples where you have

237

00:10:27,270 --> 00:10:25,300

multiple organisms present do lead us to

238

00:10:29,370 --> 00:10:27,280

believe that we are detecting beta

239

00:10:31,890 --> 00:10:29,380

carotene within the environmental

240

00:10:33,660 --> 00:10:31,900

samples and this could be a diagnostic

241

00:10:35,940 --> 00:10:33,670

peak that could be used as a bio

242

00:10:39,120 --> 00:10:35,950

signature in the future and we may be

243

00:10:42,120 --> 00:10:39,130

able to use Kwan or this may be parsed

244

00:10:44,610 --> 00:10:42,130

out and and a quantitative data could be

245

00:10:46,860 --> 00:10:44,620

used within the Raman signatures to

246

00:10:48,750 --> 00:10:46,870

understand the abundance of the beta

247

00:10:51,630 --> 00:10:48,760

carotene and trace that back to sort of

248

00:10:55,920 --> 00:10:51,640

what we're seeing from the microbiome

249

00:10:57,360 --> 00:10:55,930

data and similarly same Raman so we're

250

00:10:59,910 --> 00:10:57,370

looking at the fluid inclusions again

251
00:11:03,720 --> 00:10:59,920
and pinpointing the presence of beta

252
00:11:05,760 --> 00:11:03,730
carotene these are the corona crystals

253
00:11:07,890 --> 00:11:05,770
that we looked at and these are hey

254
00:11:08,430 --> 00:11:07,900
light hopper crystals within this is

255
00:11:12,270 --> 00:11:08,440
about

256
00:11:14,490 --> 00:11:12,280
micron scale is a submicron using again

257
00:11:17,070 --> 00:11:14,500
FTIR imaging and looking at the fluid

258
00:11:22,090 --> 00:11:17,080
inclusions within these as well as well

259
00:11:33,740 --> 00:11:22,100
as the halide hopper crystals that's it

260
00:11:39,810 --> 00:11:37,500
hey thanks um great talk I have one

261
00:11:43,740 --> 00:11:39,820
comment actually opened up the north arm

262
00:11:46,770 --> 00:11:43,750
of the salt lake now um oh okay

263
00:11:48,090 --> 00:11:46,780

hi it was just recently last fall um but

264

00:11:50,640 --> 00:11:48,100

I was also wondering you might have

265

00:11:52,890 --> 00:11:50,650

grazed by this were you extracting DNA

266

00:11:54,420 --> 00:11:52,900

from your fluid inclusions to try to get

267

00:11:57,660 --> 00:11:54,430

microbial life inside of that fluid

268

00:11:59,820 --> 00:11:57,670

inclusion yeah so the the Clay's and non

269

00:12:01,320 --> 00:11:59,830

clays we were able to separate those and

270

00:12:02,880 --> 00:12:01,330

understand that differently but the

271

00:12:04,590 --> 00:12:02,890

fluid inclusions within the hey light is

272

00:12:07,440 --> 00:12:04,600

sort of something we're still developing

273

00:12:09,390 --> 00:12:07,450

as to how we can separate the fluid

274

00:12:11,220 --> 00:12:09,400

inclusions look at that separately from

275

00:12:13,260 --> 00:12:11,230

the halide crystals so we weren't able

276

00:12:15,510 --> 00:12:13,270

to do that okay so you haven't found a

277

00:12:16,110 --> 00:12:15,520

way to sterilize the outside yeah

278

00:12:20,520 --> 00:12:16,120

exactly

279

00:12:28,540 --> 00:12:20,530

okay yeah yep we have any other

280

00:12:32,300 --> 00:12:30,590

this is really awesome study I was

281

00:12:33,800 --> 00:12:32,310

wondering kind of are you gonna plan to

282

00:12:35,930 --> 00:12:33,810

look at these kind of with ExoMars or

283

00:12:37,730 --> 00:12:35,940

MSL as good technique because you've got

284

00:12:39,800 --> 00:12:37,740

a kind of Mars 2020 raman spectroscopy

285

00:12:41,060 --> 00:12:39,810

would like laser desorption all kind of

286

00:12:44,360 --> 00:12:41,070

pyrolysis so you plan to do those

287

00:12:47,360 --> 00:12:44,370

experiments yeah we are we are trying to

288

00:12:50,000 --> 00:12:47,370

look at multiple methods to sort of

289

00:12:52,400 --> 00:12:50,010

trace back what we can see our primary

290

00:12:55,580 --> 00:12:52,410

focus is looking at wet micro lab

291

00:12:57,800 --> 00:12:55,590

techniques so the DNA extraction can be

292

00:13:00,860 --> 00:12:57,810

done and within a lab setting and sort

293

00:13:02,330 --> 00:13:00,870

of mapping that onto the data that we

294

00:13:04,880 --> 00:13:02,340

can receive from an instrument that

295

00:13:07,310 --> 00:13:04,890

could be easily mounted onto a rover or

296

00:13:08,600 --> 00:13:07,320

an orbiter so that that's our primary

297

00:13:14,060 --> 00:13:08,610

focus but yeah that's something we're

298

00:13:17,300 --> 00:13:14,070

definitely looking at thanks cool if you

299

00:13:19,970 --> 00:13:17,310

have user so field Raman or just a lab

300

00:13:22,820 --> 00:13:19,980

laboratory rapid instruments it was a

301

00:13:24,140 --> 00:13:22,830

lab rahman okay yeah you plan to do you

302

00:13:26,360 --> 00:13:24,150

plan to go to the field to do that

303

00:13:29,090 --> 00:13:26,370

directly there to see how much you can

304

00:13:30,890 --> 00:13:29,100

detect or yeah the field round we are

305

00:13:33,050 --> 00:13:30,900

we're definitely looking at field Raman

306

00:13:38,210 --> 00:13:33,060

as well to see if there are any

307

00:13:40,460 --> 00:13:38,220

differences okay well with that let's