
AbSciCon
2019

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

2
00:00:12,230 --> 00:00:09,100
[Applause]

3
00:00:14,240 --> 00:00:12,240
all right welcome everyone thank you for

4
00:00:18,920 --> 00:00:14,250
coming to this plenary session we are

5
00:00:21,109 --> 00:00:18,930
going to start we were going to focus on

6
00:00:23,000 --> 00:00:21,119
Mars so this is understanding habitats

7
00:00:25,900 --> 00:00:23,010
and searching for life on Mars latest

8
00:00:30,080 --> 00:00:25,910
results and I'll look ahead to Mars 2020

9
00:00:31,490 --> 00:00:30,090
the presenters by alphabetical order are

10
00:00:33,979 --> 00:00:31,500
Bethany Ober

11
00:00:36,920 --> 00:00:33,989
Elmen who is the co-chair with me i'm

12
00:00:40,340 --> 00:00:36,930
manuel de la torre by the way Jennifer I

13
00:00:43,189 --> 00:00:40,350

came rode over there we have Barbara

14
00:00:53,570 --> 00:00:50,270
Don Sumner Alexis Templeton and Ken will

15
00:01:00,070 --> 00:00:53,580
afford this over there all right I'll

16
00:01:18,429 --> 00:01:08,840
know and trying to figure out this

17
00:01:22,940 --> 00:01:18,439
control no that's the point so sorry

18
00:01:25,099 --> 00:01:22,950
some guidelines also based a little bit

19
00:01:28,249 --> 00:01:25,109
on the dynamics I observed on the

20
00:01:30,260 --> 00:01:28,259
plenary session yesterday so first of

21
00:01:32,469 --> 00:01:30,270
all for we're focusing on Mars habitats

22
00:01:35,389 --> 00:01:32,479
there will be some a set of introductory

23
00:01:38,149 --> 00:01:35,399
presentations of about five to seven

24
00:01:40,190 --> 00:01:38,159
minutes this will be followed by a

25
00:01:43,669 --> 00:01:40,200
session with comments and questions from

26
00:01:46,489 --> 00:01:43,679
all of you from the public and I will

27
00:01:49,639 --> 00:01:46,499
just ask everyone the main speakers as

28
00:01:52,279 --> 00:01:49,649
well as to the public to convey your

29
00:01:55,999 --> 00:01:52,289
message but please keep it brief so that

30
00:02:01,010 --> 00:01:56,009
more people can participate next slide

31
00:02:02,899 --> 00:02:01,020
is about me what am I doing here

32
00:02:04,849 --> 00:02:02,909
I do work mostly on planetary

33
00:02:06,800 --> 00:02:04,859
atmospheres I'm sort of an outsider to

34
00:02:09,350 --> 00:02:06,810
buy Astra to astrobiology but not

35
00:02:13,730 --> 00:02:09,360
completely so yes I do work on Mars and

36
00:02:15,320 --> 00:02:13,740
on earth but and right now I'm focused

37
00:02:17,240 --> 00:02:15,330
I'm working with the environmental

38
00:02:19,820 --> 00:02:17,250

themes on curiosity and in the future I

39
00:02:22,250 --> 00:02:19,830
hope to work on Mars 2020 once we

40
00:02:24,979 --> 00:02:22,260
successfully land

41
00:02:27,259 --> 00:02:24,989
and we why I'm I here why am i

42
00:02:30,020 --> 00:02:27,269
interested in this is because everyone

43
00:02:34,670 --> 00:02:30,030
knows that the environment does have a

44
00:02:36,789 --> 00:02:34,680
connection with astrobiology but we sort

45
00:02:39,319 --> 00:02:36,799
of don't talk to each other that much so

46
00:02:43,190 --> 00:02:39,329
I'm looking for those common interests

47
00:02:45,440 --> 00:02:43,200
and see how my expertise or others like

48
00:02:49,190 --> 00:02:45,450
me can be useful for your to your

49
00:02:51,610 --> 00:02:49,200
community so these are probably obvious

50
00:02:54,229 --> 00:02:51,620
facts but as a list of potential

51
00:02:58,069 --> 00:02:54,239
connections we do measure atmospheric

52
00:03:01,369 --> 00:02:58,079
composition from the Rovers that is

53
00:03:03,410 --> 00:03:01,379
related to signatures so products of

54
00:03:05,210 --> 00:03:03,420
reactions that may be really relevant

55
00:03:08,030 --> 00:03:05,220
for your analysis and models and

56
00:03:10,129 --> 00:03:08,040
availability of nutrients we do measure

57
00:03:12,259 --> 00:03:10,139
thermodynamic processes near the surface

58
00:03:13,640 --> 00:03:12,269
which tell us they've got thermal

59
00:03:15,050 --> 00:03:13,650
constraints do we have the temperatures

60
00:03:17,839 --> 00:03:15,060
we need do we have the water vapor we

61
00:03:19,729 --> 00:03:17,849
need what is the timing do we get their

62
00:03:22,550 --> 00:03:19,739
radiation levels and temperatures and

63
00:03:24,319 --> 00:03:22,560

water vapor we need at the same time we

64
00:03:25,879 --> 00:03:24,329
measure solar radiation on the surface

65
00:03:28,640 --> 00:03:25,889
and was mentioning yesterday how

66
00:03:32,420 --> 00:03:28,650
relevant that is we measure on Mars the

67
00:03:34,879 --> 00:03:32,430
dust cycle and as well as the winds

68
00:03:37,400 --> 00:03:34,889
which tell us about transport phenomena

69
00:03:41,330 --> 00:03:37,410
how to transport nutrients or even any

70
00:03:43,550 --> 00:03:41,340
biological activity we measure the

71
00:03:45,800 --> 00:03:43,560
global circulation how does anything

72
00:03:48,250 --> 00:03:45,810
spread all over the planet and as I

73
00:03:52,099 --> 00:03:48,260
mentioned earlier the hydrological cycle

74
00:03:55,220 --> 00:03:52,109
so since these environmental in situ

75
00:03:57,140 --> 00:03:55,230
observations that we do inform your

76
00:04:00,470 --> 00:03:57,150
models constrain your models that may

77
00:04:04,339 --> 00:04:00,480
even motivate new approaches or consider

78
00:04:08,050 --> 00:04:04,349
new pathways for the processes that

79
00:04:10,939 --> 00:04:08,060
you're considering my question to you

80
00:04:13,729 --> 00:04:10,949
will be what type of environmental

81
00:04:16,849 --> 00:04:13,739
investigations do you think you need for

82
00:04:19,430 --> 00:04:16,859
your models so that we can provide those

83
00:04:20,930 --> 00:04:19,440
maybe we do have the instruments but we

84
00:04:22,490 --> 00:04:20,940
haven't thought of the analysis you need

85
00:04:24,170 --> 00:04:22,500
or maybe we don't even have the

86
00:04:27,560 --> 00:04:24,180
instruments so that's what I came here

87
00:04:33,420 --> 00:04:27,570
for and with that I will just let go to

88
00:04:37,870 --> 00:04:36,040

okay so I'm Bethany Elmen professor at

89
00:04:39,550 --> 00:04:37,880
Caltech and research scientist at JPL

90
00:04:41,770 --> 00:04:39,560
and the other co-chair of this session

91
00:04:44,050 --> 00:04:41,780
as we get the my slides up I want to

92
00:04:47,080 --> 00:04:44,060
acknowledge first of all Felipe Gomez

93
00:04:48,760 --> 00:04:47,090
from the central dais Rubio Lea who was

94
00:04:50,260 --> 00:04:48,770
the other convener of this session but

95
00:04:51,760 --> 00:04:50,270
was not able to physically make it so

96
00:04:53,410 --> 00:04:51,770
thank you to Felipe and the members of

97
00:04:54,940 --> 00:04:53,420
the organizing committee for the

98
00:04:56,200 --> 00:04:54,950
opportunity to tell you about some of

99
00:04:58,060 --> 00:04:56,210
the most exciting things that are

100
00:05:01,390 --> 00:04:58,070
happening on Mars and talk about why it

101
00:05:02,770 --> 00:05:01,400
is so relevant and such a lynchpin for

102
00:05:04,750 --> 00:05:02,780
understanding habitability of

103
00:05:06,670 --> 00:05:04,760
terrestrial planets possibly including

104
00:05:08,290 --> 00:05:06,680
our own earth and I'll ask my

105
00:05:09,520 --> 00:05:08,300
co-chairman well to time me because he

106
00:05:12,160 --> 00:05:09,530
may have to pull me off the stage

107
00:05:14,470 --> 00:05:12,170
because there's so much to talk about so

108
00:05:16,230 --> 00:05:14,480
I think we're all broadly familiar with

109
00:05:19,990 --> 00:05:16,240
the timeline but I'll just remind you

110
00:05:27,670 --> 00:05:20,000
that and is there should there be a

111
00:05:29,380 --> 00:05:27,680
pointer up here folks in the back and so

112
00:05:30,820 --> 00:05:29,390
I'll just remind the folks looking at

113
00:05:32,350 --> 00:05:30,830

the timeline here of course we're all

114
00:05:34,540 --> 00:05:32,360
familiar with the timeline of our earth

115
00:05:37,360 --> 00:05:34,550
and the earliest life that we so far

116
00:05:38,950 --> 00:05:37,370
recognize over here around the 3.5 to

117
00:05:41,470 --> 00:05:38,960
three point eight range oxygenation of

118
00:05:42,850 --> 00:05:41,480
course not happening until later so it

119
00:05:44,680 --> 00:05:42,860
is around this time and it is worth

120
00:05:48,850 --> 00:05:44,690
keeping in mind that this is when Mars

121
00:05:51,040 --> 00:05:48,860
was at its most habitable so before the

122
00:05:53,700 --> 00:05:51,050
rise of oxygen on earth is where the

123
00:05:56,770 --> 00:05:53,710
action was this is expressed in terms of

124
00:05:58,720 --> 00:05:56,780
geomorphology in terms of the timing of

125
00:06:01,540 --> 00:05:58,730
Valley Networks and outflow channels the

126
00:06:03,520 --> 00:06:01,550
existence of lakes and more recently

127
00:06:05,260 --> 00:06:03,530
it's been richly expressed in the

128
00:06:07,420 --> 00:06:05,270
mineralogy that we're able to see from

129
00:06:10,540 --> 00:06:07,430
orbit and on the ground clay mineralogy

130
00:06:12,430 --> 00:06:10,550
and various salts if we collectively try

131
00:06:14,290 --> 00:06:12,440
to put this into a representation of

132
00:06:17,170 --> 00:06:14,300
habitats I think it looks something like

133
00:06:19,840 --> 00:06:17,180
this that we had sub-aerial habitats for

134
00:06:22,690 --> 00:06:19,850
life lasting until about two and a half

135
00:06:24,880 --> 00:06:22,700
billion years ago subsurface habitats

136
00:06:26,590 --> 00:06:24,890
that perhaps continue on into the

137
00:06:28,120 --> 00:06:26,600
present I say that based on the fact

138
00:06:30,340 --> 00:06:28,130

that even some of the meteorites show

139
00:06:32,170 --> 00:06:30,350
evidence of alteration and then sub

140
00:06:34,420 --> 00:06:32,180
aqueous underwater habitats that were

141
00:06:35,260 --> 00:06:34,430
intermittent so why intermittent this is

142
00:06:36,880 --> 00:06:35,270
something I think that's really

143
00:06:39,280 --> 00:06:36,890
important to keep in mind whenever we

144
00:06:40,690 --> 00:06:39,290
consider Mars and it's fundamentally

145
00:06:43,120 --> 00:06:40,700
different from Earth but it may be

146
00:06:46,270 --> 00:06:43,130
typical of terrestrial exoplanets out

147
00:06:50,230 --> 00:06:46,280
there that is Earth has a moon that's

148
00:06:52,629 --> 00:06:50,240
so we go through obliquity cycles we're

149
00:06:55,020 --> 00:06:52,639
a one-degree wobble causes massive

150
00:06:57,970 --> 00:06:55,030
climate change glaciation ice ages I'm

151
00:07:00,129 --> 00:06:57,980
showing four scale here the the Mars's

152
00:07:01,900 --> 00:07:00,139
obliquity change and the time scale over

153
00:07:04,090 --> 00:07:01,910
which it occurs which is over 500

154
00:07:07,240 --> 00:07:04,100
millions of years to five million year

155
00:07:09,670 --> 00:07:07,250
intervals and if we if we consider this

156
00:07:12,129 --> 00:07:09,680
yes there are habitable environments on

157
00:07:15,430 --> 00:07:12,139
Mars but at the surface they would have

158
00:07:18,220 --> 00:07:15,440
had a periodicity and an intermittency

159
00:07:20,560 --> 00:07:18,230
to them what does that mean for what

160
00:07:22,060 --> 00:07:20,570
life does for some of you I think that

161
00:07:22,960 --> 00:07:22,070
might be great listening to some of the

162
00:07:24,820 --> 00:07:22,970
models where you have to create

163
00:07:26,260 --> 00:07:24,830

reactants and then concentrate them so

164
00:07:26,620 --> 00:07:26,270
maybe this is intermittency is a good

165
00:07:28,480 --> 00:07:26,630
thing

166
00:07:30,700 --> 00:07:28,490
or maybe it's deleterious because it's

167
00:07:32,640 --> 00:07:30,710
hard to adapt regardless though there

168
00:07:34,360 --> 00:07:32,650
are two billion years of diverse

169
00:07:37,180 --> 00:07:34,370
environments

170
00:07:38,219 --> 00:07:37,190
these include and this is gonna be the

171
00:07:41,710 --> 00:07:38,229
quick tour

172
00:07:44,140 --> 00:07:41,720
these include open basin lakes with

173
00:07:46,900 --> 00:07:44,150
clays and carbonates we'll get to

174
00:07:50,680 --> 00:07:46,910
explore this amazing Delta and j0 crater

175
00:07:52,450 --> 00:07:50,690
with the Mars 2020 Rover so if you like

176
00:07:56,110 --> 00:07:52,460
open basin lakes for life

177
00:07:57,969 --> 00:07:56,120
Mars has them equally we have closed

178
00:07:59,620 --> 00:07:57,979
Basin lakes and you've heard the results

179
00:08:02,890 --> 00:07:59,630
from the Curiosity rover that will be

180
00:08:05,620 --> 00:08:02,900
talked about later evidence for laminae

181
00:08:07,870 --> 00:08:05,630
from lakes that lasted tens of thousands

182
00:08:10,240 --> 00:08:07,880
202 perhaps up to a million years and

183
00:08:12,550 --> 00:08:10,250
then evidence for still later multiple

184
00:08:14,469 --> 00:08:12,560
episodes of groundwater coming in and

185
00:08:16,330 --> 00:08:14,479
out through those systems up to about

186
00:08:21,250 --> 00:08:16,340
2.7 billion years based on

187
00:08:22,750 --> 00:08:21,260
potassium-argon dating we've also in the

188
00:08:24,640 --> 00:08:22,760

last few years and this is work in

189
00:08:27,100 --> 00:08:24,650
progress by Ellen Lise who's a graduate

190
00:08:28,630 --> 00:08:27,110
student at Caltech have been finding an

191
00:08:30,580 --> 00:08:28,640
increasing number of these closed basin

192
00:08:32,589 --> 00:08:30,590
lakes appear to be connected to volcanic

193
00:08:35,409 --> 00:08:32,599
systems here's an example where you can

194
00:08:37,180 --> 00:08:35,419
see volcanic cones these are plumbed the

195
00:08:39,159 --> 00:08:37,190
plumbing of lakes and terrace terrain um

196
00:08:40,959 --> 00:08:39,169
you can see volcanic cones in this lake

197
00:08:43,570 --> 00:08:40,969
and the sediments that are around the

198
00:08:47,860 --> 00:08:43,580
corner forming these beautiful stacks

199
00:08:49,990 --> 00:08:47,870
are al unite in kaolian kala night alia

200
00:08:52,780 --> 00:08:50,000
night is an acid sulfate formed by the

201
00:08:55,120 --> 00:08:52,790
disproportion a ssin of sulfuric gases

202
00:08:59,410 --> 00:08:55,130
as they reach the surface presumably in

203
00:09:00,170 --> 00:08:59,420
this Paleo Lake we also see traditional

204
00:09:02,450 --> 00:09:00,180
silica

205
00:09:04,400 --> 00:09:02,460
Hot Springs I'm showing you examples

206
00:09:07,280 --> 00:09:04,410
that we observe from orbit around

207
00:09:09,680 --> 00:09:07,290
military volcanic cone these small

208
00:09:11,630 --> 00:09:09,690
deposits of silica from Springs as well

209
00:09:13,820 --> 00:09:11,640
as the silica that was seen Institute

210
00:09:16,010 --> 00:09:13,830
inferred to be part of few marala core

211
00:09:20,860 --> 00:09:16,020
hot spring deposits at the spirit

212
00:09:23,930 --> 00:09:20,870
landing site we see evaporate ik playas

213
00:09:26,420 --> 00:09:23,940

chlorides filling basins we see other

214
00:09:29,210 --> 00:09:26,430
one other basins that are full of thick

215
00:09:31,880 --> 00:09:29,220
500 meter thick sequences of sulphate

216
00:09:34,340 --> 00:09:31,890
evaporites from from ground water's

217
00:09:36,320 --> 00:09:34,350
flowing in in these sediments so

218
00:09:38,680 --> 00:09:36,330
chloride instead of my sediment basins

219
00:09:41,900 --> 00:09:38,690
and then it's perhaps not as photogenic

220
00:09:44,930 --> 00:09:41,910
but we have an amazing exposure of the

221
00:09:47,990 --> 00:09:44,940
groundwater plumbing of Mars exposed by

222
00:09:49,970 --> 00:09:48,000
erosion in the form in in showing ridges

223
00:09:52,970 --> 00:09:49,980
of iron magnesium smectite where float

224
00:09:54,290 --> 00:09:52,980
fluid once flowed other ridges clearly

225
00:09:56,019 --> 00:09:54,300
of different chemical composition

226
00:09:58,010 --> 00:09:56,029
because they're made of Jerris site and

227
00:10:00,800 --> 00:09:58,020
still other places where there's

228
00:10:02,540 --> 00:10:00,810
evidence of carbonate and serpentine so

229
00:10:04,010 --> 00:10:02,550
this is the schematic of what those

230
00:10:05,870 --> 00:10:04,020
ridges might have looked like in terms

231
00:10:08,930 --> 00:10:05,880
of access to the underground plumbing of

232
00:10:11,120 --> 00:10:08,940
Mars so 2 billion years of diverse

233
00:10:12,980 --> 00:10:11,130
ancient paleo habitats everywhere that

234
00:10:18,230 --> 00:10:12,990
there's a dot on here is a place that I

235
00:10:21,050 --> 00:10:18,240
do not have time to talk about but

236
00:10:22,910 --> 00:10:21,060
that's not all ok Mars has gotten them

237
00:10:25,790 --> 00:10:22,920
closer we have looked in the modern time

238
00:10:27,620 --> 00:10:25,800

Mars has gotten more active there were

239
00:10:29,960 --> 00:10:27,630
hints of this scene with the spirit

240
00:10:33,019 --> 00:10:29,970
rover these are salts buried just this

241
00:10:36,350 --> 00:10:33,029
far underground meaning that they're

242
00:10:39,050 --> 00:10:36,360
pretty recent right and there's sulfate

243
00:10:40,760 --> 00:10:39,060
chemistry now is this because when Mars

244
00:10:43,400 --> 00:10:40,770
goes through those oblique Whitty cycles

245
00:10:45,019 --> 00:10:43,410
even 500,000 years ago liquid water was

246
00:10:49,310 --> 00:10:45,029
more stable on the surface than it is

247
00:10:52,190 --> 00:10:49,320
today there's been hints of groundwater

248
00:10:54,800 --> 00:10:52,200
or say at all have proposed an

249
00:10:56,840 --> 00:10:54,810
underground ice pond for some of the

250
00:10:59,360 --> 00:10:56,850
radar observations of the South Pole and

251
00:11:02,300 --> 00:10:59,370
others have proposed that these slope

252
00:11:05,180 --> 00:11:02,310
streaks on craters could be groundwater

253
00:11:07,569 --> 00:11:05,190
others have proposed they are not but is

254
00:11:09,530 --> 00:11:07,579
there ground water on Mars

255
00:11:11,150 --> 00:11:09,540
finally and you've all heard the

256
00:11:13,910 --> 00:11:11,160
evidence of the recent activity of

257
00:11:15,470 --> 00:11:13,920
methane why does Mars episodic

258
00:11:17,750 --> 00:11:15,480
produced methane there's clearly

259
00:11:20,449 --> 00:11:17,760
activity is that life is it volcanism is

260
00:11:22,220 --> 00:11:20,459
it hydrothermal ISM so I think these

261
00:11:24,440 --> 00:11:22,230
questions are extremely important as we

262
00:11:25,940 --> 00:11:24,450
look outward with exoplanets and inward

263
00:11:27,319 --> 00:11:25,950

in our solar system to understand the

264
00:11:28,910 --> 00:11:27,329
habitability of terrestrial planets I

265
00:11:31,370 --> 00:11:28,920
want to leave you in my 15 seconds

266
00:11:32,660 --> 00:11:31,380
remaining with three questions that I

267
00:11:35,180 --> 00:11:32,670
want you to consider and maybe come up

268
00:11:37,370 --> 00:11:35,190
given this 2 billion year old rich

269
00:11:39,290 --> 00:11:37,380
record in multiple sites how do we do

270
00:11:40,610 --> 00:11:39,300
this as planetary scientists when we

271
00:11:42,259 --> 00:11:40,620
have a limited number of missions how do

272
00:11:45,470 --> 00:11:42,269
we know when our search for life

273
00:11:47,259 --> 00:11:45,480
paleo life is complete on Mars and would

274
00:11:50,210 --> 00:11:47,269
it would it look different than on earth

275
00:11:51,710 --> 00:11:50,220
finally given this modern Mars activity

276
00:11:53,990 --> 00:11:51,720
how do we determine whether there is

277
00:11:55,430 --> 00:11:54,000
life on Mars now what specific sites do

278
00:11:57,560 --> 00:11:55,440
we go to to answer that question

279
00:11:58,850 --> 00:11:57,570
Mars is a rich world for astrobiology

280
00:12:03,600 --> 00:11:58,860
and I hope we architect the plan to

281
00:12:03,610 --> 00:12:23,079
[Applause]

282
00:12:29,900 --> 00:12:27,650
yeah I'm not sure if I have slides or

283
00:12:33,470 --> 00:12:29,910
not they're beautiful okay excellent so

284
00:12:38,410 --> 00:12:33,480
so in spite of the diverse Suites of

285
00:12:42,590 --> 00:12:38,420
habitats that are potential on Mars the

286
00:12:45,530 --> 00:12:42,600
community has chosen for both Curiosity

287
00:12:49,670 --> 00:12:45,540
rover and Mars 2020 to look at lake

288
00:12:53,179 --> 00:12:49,680

environments and this is a lake in

289
00:12:56,809 --> 00:12:53,189
Antarctica lake Frick Sol and even when

290
00:12:58,579 --> 00:12:56,819
the external climate is harsh this is

291
00:13:01,400 --> 00:12:58,589
one of the harshest places on earth it's

292
00:13:04,240 --> 00:13:01,410
still much wetter and warmer than the

293
00:13:06,530 --> 00:13:04,250
surface of Mars we end up with luxury

294
00:13:08,829 --> 00:13:06,540
ecosystems in these lakes and the large

295
00:13:12,400 --> 00:13:08,839
part of that is because of the the

296
00:13:16,910 --> 00:13:12,410
duration of liquid water and also the

297
00:13:21,049 --> 00:13:16,920
accumulation of resources from the

298
00:13:23,150 --> 00:13:21,059
surrounding so in the Antarctic Lakes I

299
00:13:24,980 --> 00:13:23,160
go to study them to understand the

300
00:13:26,689 --> 00:13:24,990
microbial communities in large part

301
00:13:29,749 --> 00:13:26,699
because there aren't large organisms

302
00:13:31,999 --> 00:13:29,759
eating them and the pinnacles in the

303
00:13:35,240 --> 00:13:32,009
lower part here are several centimeters

304
00:13:37,730 --> 00:13:35,250
high and represent structures we don't

305
00:13:41,319 --> 00:13:37,740
think could possibly form in the absence

306
00:13:44,960 --> 00:13:41,329
of life we have not found those on Mars

307
00:13:49,160 --> 00:13:44,970
with the Curiosity rover for sure but we

308
00:13:50,990 --> 00:13:49,170
have found a very long-lived lake and so

309
00:13:55,429 --> 00:13:51,000
this those same stones in the foreground

310
00:13:58,509 --> 00:13:55,439
here are Delta deposits from going from

311
00:14:02,749 --> 00:13:58,519
a river system into a la costura system

312
00:14:05,329 --> 00:14:02,759
and most of what you see up here these

313
00:14:07,879 --> 00:14:05,339

are dark sand dunes but a lot we have

314
00:14:11,569 --> 00:14:07,889
tens of meters of lacustrine mud stones

315
00:14:13,400 --> 00:14:11,579
and the interpretation of the team is

316
00:14:15,910 --> 00:14:13,410
that you have to have had a lake there

317
00:14:18,950 --> 00:14:15,920
for a very extended period of time

318
00:14:22,880 --> 00:14:18,960
billions of years ago

319
00:14:25,760 --> 00:14:22,890
and lakes are particularly good because

320
00:14:29,840 --> 00:14:25,770
they integrate things from the watershed

321
00:14:33,260 --> 00:14:29,850
that feeds into them the gale crater had

322
00:14:35,870 --> 00:14:33,270
river systems flowing in and a lot of

323
00:14:37,490 --> 00:14:35,880
the minerals that we see are basaltic

324
00:14:41,600 --> 00:14:37,500
minerals we have a lot of amorphous

325
00:14:44,780 --> 00:14:41,610
minerals and as Jen will talk about we

326
00:14:47,600 --> 00:14:44,790
have a complex organic matter within

327
00:14:49,280 --> 00:14:47,610
these and one of the nice things about

328
00:14:51,769 --> 00:14:49,290
Lakes we've also seen changes for

329
00:14:53,480 --> 00:14:51,779
example between there's there's some of

330
00:14:55,670 --> 00:14:53,490
the deposits that contain high potassium

331
00:14:58,130 --> 00:14:55,680
including some potassium feldspar as as

332
00:15:01,460 --> 00:14:58,140
others that don't and they're basically

333
00:15:03,860 --> 00:15:01,470
taking bits of the landscape around them

334
00:15:06,290 --> 00:15:03,870
and integrating them into one place so

335
00:15:09,410 --> 00:15:06,300
by going to a lake you're both sampling

336
00:15:11,690 --> 00:15:09,420
the watershed and you're also combining

337
00:15:16,340 --> 00:15:11,700
materials that are intrinsically in

338
00:15:18,199 --> 00:15:16,350

disequilibrium life lives on that

339
00:15:20,199 --> 00:15:18,209
disequilibrium now one of the

340
00:15:22,579 --> 00:15:20,209
unfortunate things is when you observe

341
00:15:24,440 --> 00:15:22,589
disequilibrium it proves that life has

342
00:15:26,840 --> 00:15:24,450
not reached its full potential in that

343
00:15:32,449 --> 00:15:26,850
habitat it hasn't actually helped drive

344
00:15:37,519 --> 00:15:32,459
things to equilibrium the Mars 2020

345
00:15:40,130 --> 00:15:37,529
Rover is going to DES row as Bethany

346
00:15:41,840 --> 00:15:40,140
mentioned and it provides a really

347
00:15:43,670 --> 00:15:41,850
outstanding opportunity where we

348
00:15:47,630 --> 00:15:43,680
actually have the prefer preserved

349
00:15:50,000 --> 00:15:47,640
morphology of the Lake Basin and the

350
00:15:52,370 --> 00:15:50,010
river system in the watershed Gale

351
00:15:54,050 --> 00:15:52,380
Crater some of us had confidence that

352
00:15:56,750 --> 00:15:54,060
there was a lake there once it's deep

353
00:15:58,460 --> 00:15:56,760
and at the equator but we had no

354
00:16:00,199 --> 00:15:58,470
evidence that there were lake deposits

355
00:16:03,050 --> 00:16:00,209
before we landed and before we did our

356
00:16:06,290 --> 00:16:03,060
field investigations in this particular

357
00:16:08,540 --> 00:16:06,300
case there was very strong evidence that

358
00:16:12,500 --> 00:16:08,550
we had a standing body of water long

359
00:16:18,639 --> 00:16:12,510
enough to deposit a significant Delta

360
00:16:25,490 --> 00:16:23,030
so if life existed on Mars we have

361
00:16:29,390 --> 00:16:25,500
several scenarios about the long-term

362
00:16:31,190 --> 00:16:29,400
habitability this is after Cocola at all

363
00:16:32,300 --> 00:16:31,200

and I really like the idea so you have

364
00:16:34,550 --> 00:16:32,310
sort of the

365
00:16:37,550 --> 00:16:34,560
the evolution and the proliferation of

366
00:16:41,500 --> 00:16:37,560
life that inhabits a wide variety of

367
00:16:45,170 --> 00:16:41,510
environments yellow here is an inhabited

368
00:16:47,600 --> 00:16:45,180
environment but you can also have areas

369
00:16:50,930 --> 00:16:47,610
even if there is life on Mars that life

370
00:16:54,040 --> 00:16:50,940
was unable to colonize those sorts of

371
00:16:56,720 --> 00:16:54,050
environments so those could be Lakes or

372
00:16:58,970 --> 00:16:56,730
subsurface areas with liquid water and

373
00:17:00,710 --> 00:16:58,980
so when you're actually looking for

374
00:17:02,470 --> 00:17:00,720
evidence of life on Mars and trying to

375
00:17:07,699 --> 00:17:02,480
understand it there's both the

376
00:17:10,490 --> 00:17:07,709
habitability and the presence of life if

377
00:17:12,650 --> 00:17:10,500
it exists so there are two scenarios so

378
00:17:14,960 --> 00:17:12,660
say we have a life in the subsurface

379
00:17:16,760 --> 00:17:14,970
maybe it still exists there's there are

380
00:17:19,640 --> 00:17:16,770
two different scenarios for how it went

381
00:17:22,760 --> 00:17:19,650
extinct if it ever existed one is that

382
00:17:26,540 --> 00:17:22,770
it was unable to persist in colonize

383
00:17:28,309 --> 00:17:26,550
from a habitable environment to newly a

384
00:17:30,820 --> 00:17:28,319
habitable environment say there's a

385
00:17:34,550 --> 00:17:30,830
disconnect and an inability to colonize

386
00:17:36,410 --> 00:17:34,560
which can cause extinction and then

387
00:17:38,120 --> 00:17:36,420
there's also the question about whether

388
00:17:41,720 --> 00:17:38,130

they're habitable environments

389
00:17:44,180 --> 00:17:41,730
disappeared and we don't know whether or

390
00:17:46,310 --> 00:17:44,190
not there was ever life on Mars but when

391
00:17:48,620 --> 00:17:46,320
we're looking at these places we can go

392
00:17:51,169 --> 00:17:48,630
it's really important to understand that

393
00:17:53,540 --> 00:17:51,179
just because something's habitable and

394
00:17:55,910 --> 00:17:53,550
not inhabited doesn't mean there's not

395
00:17:57,620 --> 00:17:55,920
life there but and just because

396
00:18:01,370 --> 00:17:57,630
something's habitable does not mean that

397
00:18:07,220 --> 00:18:01,380
there was actually a life there to take

398
00:18:12,020 --> 00:18:07,230
advantage of those resources yep so Mars

399
00:18:15,110 --> 00:18:12,030
2020 will be exploring the toe of this

400
00:18:18,050 --> 00:18:15,120
Delta that's coming down through here

401
00:18:20,090 --> 00:18:18,060
and one of the amazing things about Mars

402
00:18:22,430 --> 00:18:20,100
is a lot of the physics and chemistry

403
00:18:25,520 --> 00:18:22,440
are the same and we end up with amazing

404
00:18:29,090 --> 00:18:25,530
landscapes and whether or not this is

405
00:18:30,910 --> 00:18:29,100
inhabited by life or ever was it so it's

406
00:18:34,010 --> 00:18:30,920
an amazing and inspiring place to

407
00:18:39,630 --> 00:18:34,020
explore to actually look for that

408
00:18:53,130 --> 00:18:40,800
[Music]

409
00:18:59,049 --> 00:18:57,520
okay so I want to kind of extrapolate a

410
00:19:01,270 --> 00:18:59,059
little bit more on some of the things

411
00:19:04,840 --> 00:19:01,280
that have already been said and talk

412
00:19:08,680 --> 00:19:04,850
about carbon on Mars now there has been

413
00:19:10,270 --> 00:19:08,690

in the last four years this wave of new

414
00:19:12,820 --> 00:19:10,280
observations that have come from the

415
00:19:16,810 --> 00:19:12,830
surface of Mars from the Curiosity River

416
00:19:18,910 --> 00:19:16,820
and so if you look up in the upper right

417
00:19:21,190 --> 00:19:18,920
upper left-hand side one of the first

418
00:19:23,560 --> 00:19:21,200
observations that came out was about

419
00:19:26,320 --> 00:19:23,570
chlorinated molecules including things

420
00:19:29,680 --> 00:19:26,330
like carbon molecules that have up to

421
00:19:33,250 --> 00:19:29,690
four carbons in a chain or benzene that

422
00:19:37,330 --> 00:19:33,260
has a carbon chlorine attached to it now

423
00:19:39,490 --> 00:19:37,340
when we found these molecules we weren't

424
00:19:41,350 --> 00:19:39,500
quite sure what they meant these are not

425
00:19:43,660 --> 00:19:41,360
things that you typically find in

426
00:19:44,919 --> 00:19:43,670
natural samples here on earth and so it

427
00:19:46,600 --> 00:19:44,929
was kind of perplexing how do we

428
00:19:48,850 --> 00:19:46,610
interpret this what does this really

429
00:19:50,919 --> 00:19:48,860
tell us what does it mean and our

430
00:19:52,810 --> 00:19:50,929
thought was we're gonna move on you know

431
00:19:55,120 --> 00:19:52,820
maybe we're going to find another

432
00:19:58,419 --> 00:19:55,130
treasure trove of molecule somewhere

433
00:20:00,070 --> 00:19:58,429
else and indeed we did as we move from

434
00:20:03,160 --> 00:20:00,080
the first lake environment at

435
00:20:04,690 --> 00:20:03,170
Yellowknife Bay we moved on to an area

436
00:20:06,730 --> 00:20:04,700
called Pahrump Hills where we had came

437
00:20:09,130 --> 00:20:06,740
across the murray formation at the base

438
00:20:13,390 --> 00:20:09,140

of the murray formation which is shown

439
00:20:16,510 --> 00:20:13,400
on the upper right-hand side we found a

440
00:20:18,940 --> 00:20:16,520
whole bunch of other signals in the Sam

441
00:20:22,419 --> 00:20:18,950
instrument this is the sample analysis

442
00:20:24,430 --> 00:20:22,429
at Mars instrument and it's a GCMs but

443
00:20:27,120 --> 00:20:24,440
what it does is two different types of

444
00:20:30,040 --> 00:20:27,130
analyses evolve gas analysis and gc/ms

445
00:20:32,430 --> 00:20:30,050
the it's not at this point I don't want

446
00:20:34,810 --> 00:20:32,440
to explain exactly what those are but

447
00:20:37,060 --> 00:20:34,820
it's important because it gives us two

448
00:20:39,190 --> 00:20:37,070
different insights into what we're

449
00:20:42,280 --> 00:20:39,200
coming across this type of chemistry

450
00:20:45,520 --> 00:20:42,290
that's there and what we found was that

451
00:20:47,470 --> 00:20:45,530
when we heated up samples we actually

452
00:20:50,650 --> 00:20:47,480
generated a whole bunch of small little

453
00:20:53,080 --> 00:20:50,660
molecules and those molecules

454
00:20:54,730 --> 00:20:53,090
I have all different types of chemistry

455
00:20:56,740 --> 00:20:54,740
some of them are aromatic meaning their

456
00:20:59,380 --> 00:20:56,750
ring structures some of them are hard

457
00:21:02,350 --> 00:20:59,390
your carbon chains some of them had

458
00:21:04,570 --> 00:21:02,360
sulfur in them well when we put all of

459
00:21:06,280 --> 00:21:04,580
those observations together it tells us

460
00:21:08,650 --> 00:21:06,290
that there was a refractory organic

461
00:21:10,930 --> 00:21:08,660
material present this is organic matter

462
00:21:13,360 --> 00:21:10,940
the way we think of organic matter in

463
00:21:15,910 --> 00:21:13,370

most natural samples whether it's on

464
00:21:18,100 --> 00:21:15,920
earth or in a meteorite these are the

465
00:21:22,180 --> 00:21:18,110
types of molecules that we would expect

466
00:21:24,580 --> 00:21:22,190
if we had something that was larger than

467
00:21:26,350 --> 00:21:24,590
themselves and when we heat up the

468
00:21:28,690 --> 00:21:26,360
samples they break down into smaller

469
00:21:30,490 --> 00:21:28,700
molecules so I show in the middle there

470
00:21:33,060 --> 00:21:30,500
there's a little video here as two

471
00:21:35,080 --> 00:21:33,070
molecules propane and benzene and

472
00:21:36,970 --> 00:21:35,090
essentially what they are at little

473
00:21:41,140 --> 00:21:36,980
components of something bigger this is a

474
00:21:44,350 --> 00:21:41,150
macro molecule we found something we

475
00:21:45,670 --> 00:21:44,360
found it and it's it makes more sense

476
00:21:47,800 --> 00:21:45,680
now

477
00:21:50,830 --> 00:21:47,810
the question though is how does this

478
00:21:53,410 --> 00:21:50,840
relate back to the prior observations of

479
00:21:54,910 --> 00:21:53,420
the chlorinated hydrocarbons well it

480
00:21:57,880 --> 00:21:54,920
ends up that when you take stuff like

481
00:21:59,350 --> 00:21:57,890
this and you bombard it with a whole

482
00:22:01,750 --> 00:21:59,360
bunch of radiation particularly in the

483
00:22:04,270 --> 00:22:01,760
presence of salts that have chlorine you

484
00:22:06,640 --> 00:22:04,280
actually break it down into smaller and

485
00:22:08,680 --> 00:22:06,650
smaller molecules and they get oxygens

486
00:22:11,500 --> 00:22:08,690
attached to them and they're easy to

487
00:22:13,960 --> 00:22:11,510
chlorinate and so it could be and this

488
00:22:15,580 --> 00:22:13,970

is a hypothesis it could be that what

489
00:22:18,700 --> 00:22:15,590
we're really dealing with is in one

490
00:22:21,730 --> 00:22:18,710
place we came across as more refractory

491
00:22:24,160 --> 00:22:21,740
complex large organic materials with

492
00:22:25,690 --> 00:22:24,170
sulfur in them and over time in other

493
00:22:28,000 --> 00:22:25,700
places they had broken down into

494
00:22:29,530 --> 00:22:28,010
something as simple as the chlorinated

495
00:22:31,930 --> 00:22:29,540
hydrocarbons and that's what's left

496
00:22:33,630 --> 00:22:31,940
behind well there's been more

497
00:22:36,270 --> 00:22:33,640
observations it's just not these two

498
00:22:38,680 --> 00:22:36,280
there's a recent observation of

499
00:22:40,440 --> 00:22:38,690
hydrocarbon chains and that's show in

500
00:22:44,680 --> 00:22:40,450
the bottom left-hand side here and

501
00:22:47,050 --> 00:22:44,690
there's a carbon chains that have C 11 3

502
00:22:49,480 --> 00:22:47,060
10 through C 12 that might be present

503
00:22:53,650 --> 00:22:49,490
and we're surely still trying to

504
00:22:55,450 --> 00:22:53,660
understand the what the significance of

505
00:22:57,610 --> 00:22:55,460
this observation is but for the first

506
00:22:59,260 --> 00:22:57,620
time we have individual molecules that

507
00:23:02,290 --> 00:22:59,270
are larger than what we have previously

508
00:23:04,450 --> 00:23:02,300
seen so this is it this is another clue

509
00:23:06,880 --> 00:23:04,460
of things that are happening

510
00:23:09,220 --> 00:23:06,890
or or a record that is still intact

511
00:23:10,390 --> 00:23:09,230
somewhere in these rocks and then of

512
00:23:13,330 --> 00:23:10,400
course we have the methane detections

513
00:23:16,540 --> 00:23:13,340

that are shown in the bottom right hand

514
00:23:20,440 --> 00:23:16,550
side and this is a plot that was shown

515
00:23:23,580 --> 00:23:20,450
back in 2018 and it shows a fluctuation

516
00:23:26,770 --> 00:23:23,590
in the methane signal related to seasons

517
00:23:29,140 --> 00:23:26,780
now what's um particularly interesting

518
00:23:31,930 --> 00:23:29,150
at this point is that the scale bar on

519
00:23:33,820 --> 00:23:31,940
this goes up to about 0.7 there was an

520
00:23:36,520 --> 00:23:33,830
observation after this it goes up to

521
00:23:39,310 --> 00:23:36,530
about 7 parts per million parts per

522
00:23:41,500 --> 00:23:39,320
billion methane but of course we just

523
00:23:45,010 --> 00:23:41,510
had the announcement that there's up to

524
00:23:46,690 --> 00:23:45,020
21 parts per billion so on this scale

525
00:23:52,330 --> 00:23:46,700
that would be upstairs on the third

526
00:23:54,700 --> 00:23:52,340
floor but there's a lot more to the

527
00:23:56,050 --> 00:23:54,710
carbon story we have evidence from

528
00:23:58,000 --> 00:23:56,060
Martian meteorites that there's all

529
00:24:01,870 --> 00:23:58,010
sorts of carbon present and it's it's

530
00:24:04,750 --> 00:24:01,880
been a very labor-intensive process to

531
00:24:06,430 --> 00:24:04,760
go through and pick through the little

532
00:24:08,380 --> 00:24:06,440
tidbits of organic matter in those

533
00:24:11,170 --> 00:24:08,390
Martian meters to try and understand

534
00:24:13,420 --> 00:24:11,180
what is there those are telling us

535
00:24:14,980 --> 00:24:13,430
things about Mars butts different than

536
00:24:16,960 --> 00:24:14,990
these lake environments that we have

537
00:24:19,030 --> 00:24:16,970
been studying with the rover there's

538
00:24:21,400 --> 00:24:19,040

also things like Intertek interplanetary

539
00:24:23,830 --> 00:24:21,410
dust particles raining down onto the

540
00:24:25,660 --> 00:24:23,840
surface of Mars constantly and somehow

541
00:24:27,970 --> 00:24:25,670
these can get incorporated into

542
00:24:29,830 --> 00:24:27,980
different types of rocks and sediments

543
00:24:32,860 --> 00:24:29,840
through the course of processing on the

544
00:24:34,960 --> 00:24:32,870
surface all of this can contribute to

545
00:24:37,570 --> 00:24:34,970
our carbon story and the little bits of

546
00:24:39,730 --> 00:24:37,580
insight that we get now what I think is

547
00:24:42,070 --> 00:24:39,740
particularly interesting is that there

548
00:24:44,080 --> 00:24:42,080
was a paper that came out last year in

549
00:24:46,630 --> 00:24:44,090
science advances by Andrew Steele and

550
00:24:50,080 --> 00:24:46,640
co-authors and it's really kind of

551
00:24:51,490 --> 00:24:50,090
pointing to something that we're not

552
00:24:53,140 --> 00:24:51,500
used to thinking about here on earth

553
00:24:55,000 --> 00:24:53,150
because it's not prominent here on earth

554
00:24:57,880 --> 00:24:55,010
or if it is we haven't we don't really

555
00:25:00,580 --> 00:24:57,890
see it too much but I've nicknamed it

556
00:25:02,560 --> 00:25:00,590
the Martian organic factory because

557
00:25:06,370 --> 00:25:02,570
really what it is is basaltic minerals

558
00:25:09,070 --> 00:25:06,380
salts and brines working together to

559
00:25:13,000 --> 00:25:09,080
basically cause a geochemical corrosion

560
00:25:15,490 --> 00:25:13,010
that isn't it it's it's a battery and a

561
00:25:17,590 --> 00:25:15,500
stimulating electrochemistry and as a

562
00:25:19,239 --> 00:25:17,600
result of that electrochemistry

563
00:25:22,930 --> 00:25:19,249

it can actually produce organic

564
00:25:25,239 --> 00:25:22,940
molecules it takes co2 and reduces it so

565
00:25:27,609 --> 00:25:25,249
perhaps some of these organic molecules

566
00:25:29,609 --> 00:25:27,619
that we're picking up maybe they're

567
00:25:32,710 --> 00:25:29,619
coming from interplanted dust particles

568
00:25:34,930 --> 00:25:32,720
maybe they're coming from this Martian

569
00:25:36,940 --> 00:25:34,940
organic chew chemical factory of

570
00:25:39,729 --> 00:25:36,950
producing or yes maybe they're coming

571
00:25:41,739 --> 00:25:39,739
from some we know ancient form of life

572
00:25:47,080 --> 00:25:41,749
we don't really know that's a big

573
00:25:49,899 --> 00:25:47,090
question so but the point I want to take

574
00:25:51,549 --> 00:25:49,909
a take away from this is that we have a

575
00:25:54,129 --> 00:25:51,559
new set of observations and our

576
00:25:56,769 --> 00:25:54,139
perspective of carbon in general on Mars

577
00:25:59,769 --> 00:25:56,779
has changed and what was a seemingly

578
00:26:02,560 --> 00:25:59,779
stagnant place may be is actually active

579
00:26:04,180 --> 00:26:02,570
we have a carbon cycle and right now we

580
00:26:06,729 --> 00:26:04,190
need to start working towards

581
00:26:08,799 --> 00:26:06,739
understanding not just sources but also

582
00:26:10,659 --> 00:26:08,809
the processes that are influencing how

583
00:26:14,370 --> 00:26:10,669
that carbon moves around the planet as a

584
00:26:18,770 --> 00:26:14,720
[Applause]

585
00:26:28,880 --> 00:26:18,780
[Music]

586
00:26:32,070 --> 00:26:30,330
thank you

587
00:26:33,750 --> 00:26:32,080
so I'm Alexis Templeton from the

588
00:26:35,520 --> 00:26:33,760

University of Colorado and the rock

589
00:26:38,040 --> 00:26:35,530
powered life NASA Astrobiology Institute

590
00:26:39,810 --> 00:26:38,050
and I was asked to actually take us back

591
00:26:42,630 --> 00:26:39,820
to earth a little bit but to talk about

592
00:26:44,760 --> 00:26:42,640
some of our recent exploration looking

593
00:26:46,500 --> 00:26:44,770
for extant life and fossilized life in

594
00:26:48,060 --> 00:26:46,510
hard rock systems and where we've been

595
00:26:50,130 --> 00:26:48,070
looking at rocks that have undergone at

596
00:26:51,660 --> 00:26:50,140
least partial hydration and often

597
00:26:54,060 --> 00:26:51,670
carbonation and how do you try and

598
00:26:57,900 --> 00:26:54,070
detect life activity again that might

599
00:26:59,640 --> 00:26:57,910
have relevance for Mars and the

600
00:27:01,170 --> 00:26:59,650
environment that I want to just take a

601
00:27:03,570 --> 00:27:01,180
few moments to put into your mind today

602
00:27:06,180 --> 00:27:03,580
is one here where on earth we can often

603
00:27:09,480 --> 00:27:06,190
have uplifted sections of mantle rock or

604
00:27:11,910 --> 00:27:09,490
peridotite ultramafic rocks that have

605
00:27:14,040 --> 00:27:11,920
undergone prior water rock interaction

606
00:27:16,380 --> 00:27:14,050
histories oftentimes on the sea floor or

607
00:27:18,480 --> 00:27:16,390
an earlier history of their behavior now

608
00:27:21,240 --> 00:27:18,490
they're sitting in this case in Oman in

609
00:27:23,520 --> 00:27:21,250
a desert environment highly arid and a

610
00:27:25,350 --> 00:27:23,530
low level of hydrological activity in

611
00:27:27,480 --> 00:27:25,360
terms of both recharge and discharge

612
00:27:29,070 --> 00:27:27,490
from these systems what's incredible

613
00:27:30,480 --> 00:27:29,080

though when we go and we start probing

614
00:27:32,250 --> 00:27:30,490
into the subsurface in these

615
00:27:35,160 --> 00:27:32,260
environments is that actually the

616
00:27:37,200 --> 00:27:35,170
storativity of water is enormous so it's

617
00:27:40,290 --> 00:27:37,210
a norm it's a giant aquifer through

618
00:27:42,750 --> 00:27:40,300
kilometer a depth and both laterally

619
00:27:44,430 --> 00:27:42,760
that's storing water and under

620
00:27:45,930 --> 00:27:44,440
conditions that are surprising in a

621
00:27:48,690 --> 00:27:45,940
limit fit where we could look for

622
00:27:50,310 --> 00:27:48,700
potential life activity and then we have

623
00:27:52,020 --> 00:27:50,320
bleed outs of fluids that have been

624
00:27:54,320 --> 00:27:52,030
stored for long periods of times long

625
00:27:57,240 --> 00:27:54,330
fracture systems and faults that

626
00:27:58,920 --> 00:27:57,250
delivers both biota and gases that have

627
00:27:59,960 --> 00:27:58,930
been produced over long time periods in

628
00:28:02,550 --> 00:27:59,970
the subsurface

629
00:28:04,650 --> 00:28:02,560
so in particular methane is one of the

630
00:28:07,530 --> 00:28:04,660
products that we see and the idea again

631
00:28:09,030 --> 00:28:07,540
is to remem remember imagine that these

632
00:28:11,160 --> 00:28:09,040
rocks are being held off in at low

633
00:28:12,810 --> 00:28:11,170
temperatures so we're well under 50

634
00:28:14,880 --> 00:28:12,820
degrees C and sometimes it just a

635
00:28:16,530 --> 00:28:14,890
surface temperature we're not cold but

636
00:28:20,700 --> 00:28:16,540
there's nothing hydrothermal occurring

637
00:28:22,470 --> 00:28:20,710
here we've been drilling into the deep

638
00:28:25,110 --> 00:28:22,480

subsurface usually over hundreds of

639
00:28:26,910 --> 00:28:25,120
meters we have about a kilometer of

640
00:28:28,020 --> 00:28:26,920
continuous core now at this point in

641
00:28:30,690 --> 00:28:28,030
time where we're searching for the

642
00:28:31,890 --> 00:28:30,700
distribution of life activity and one of

643
00:28:32,550 --> 00:28:31,900
the notable things even as we're

644
00:28:34,080 --> 00:28:32,560
drilling is

645
00:28:36,240 --> 00:28:34,090
you only have to go meters into the

646
00:28:38,370 --> 00:28:36,250
subsurface on earth with a toxic

647
00:28:40,860 --> 00:28:38,380
atmosphere to scrub out almost all signs

648
00:28:42,870 --> 00:28:40,870
of molecular oxygen so in this case

649
00:28:44,610 --> 00:28:42,880
we're sitting with atmosphere that's

650
00:28:47,250 --> 00:28:44,620
been percolating into these rocks over

651
00:28:49,560 --> 00:28:47,260
80 million years over 20 meters we've

652
00:28:51,720 --> 00:28:49,570
already removed all oxygen from fluids

653
00:28:54,630 --> 00:28:51,730
and you move in the rock system into

654
00:28:56,550 --> 00:28:54,640
highly anoxic iron to rich rocks that

655
00:28:58,070 --> 00:28:56,560
are buffering the a crispier chemistry

656
00:29:04,530 --> 00:28:58,080
and the conditions under which life

657
00:29:06,390 --> 00:29:04,540
functioning and we can probe this for

658
00:29:09,000 --> 00:29:06,400
microbial activity into a series of

659
00:29:10,710 --> 00:29:09,010
different regimes the majority of our

660
00:29:12,570 --> 00:29:10,720
focus is typically on areas where

661
00:29:14,640 --> 00:29:12,580
there's large chemical dekes equilibria

662
00:29:16,200 --> 00:29:14,650
it's often a guidepost for the ways we

663
00:29:18,750 --> 00:29:16,210

try and hunt for life activity and

664
00:29:20,580 --> 00:29:18,760
subsurface systems so for example can

665
00:29:23,640 --> 00:29:20,590
often look at areas in mid-point redox

666
00:29:24,930 --> 00:29:23,650
potentials in PH and we have no question

667
00:29:26,250 --> 00:29:24,940
there in terms of looking at quite

668
00:29:28,980 --> 00:29:26,260
diverse and functionally active

669
00:29:30,420 --> 00:29:28,990
communities my goal today is actually to

670
00:29:31,890 --> 00:29:30,430
take you to a much more extreme

671
00:29:33,630 --> 00:29:31,900
condition the one that I think might be

672
00:29:35,430 --> 00:29:33,640
very important and relevant for Mars

673
00:29:37,740 --> 00:29:35,440
which would be coming to the sort of

674
00:29:40,200 --> 00:29:37,750
lowest redox potentials being poised on

675
00:29:41,910 --> 00:29:40,210
the stability limit of water we can hold

676
00:29:43,740 --> 00:29:41,920
water under that condition for a very

677
00:29:45,660 --> 00:29:43,750
long period of time and we see

678
00:29:47,970 --> 00:29:45,670
biological activity under those states

679
00:29:51,720 --> 00:29:47,980
the issue in these is not whether

680
00:29:53,730 --> 00:29:51,730
there's a hydrogen or carbon or energy

681
00:29:55,620 --> 00:29:53,740
sources electron donors for growth it's

682
00:29:58,650 --> 00:29:55,630
getting oxidants and then the carbon

683
00:30:00,510 --> 00:29:58,660
needed to synthesize biomass and if you

684
00:30:02,370 --> 00:30:00,520
don't have fluid circulation if you're

685
00:30:03,870 --> 00:30:02,380
not hydro thermally active or having a

686
00:30:04,890 --> 00:30:03,880
large amount of convection how do you

687
00:30:09,270 --> 00:30:04,900
continue to function

688
00:30:11,190 --> 00:30:09,280

that's the enigma so what we're trying

689
00:30:13,380 --> 00:30:11,200
to refine at the moment our strategies

690
00:30:15,060 --> 00:30:13,390
how do we go through again many cubic

691
00:30:17,100 --> 00:30:15,070
kilometers of rock hunting for the

692
00:30:19,440 --> 00:30:17,110
interfaces and where life is localized

693
00:30:21,020 --> 00:30:19,450
that's able to continue to persistent

694
00:30:23,220 --> 00:30:21,030
function under these kinds of aqueous

695
00:30:25,200 --> 00:30:23,230
geochemical conditions and in the rock

696
00:30:27,870 --> 00:30:25,210
hosted environment and to the

697
00:30:29,220 --> 00:30:27,880
metabolisms were tracing the most

698
00:30:31,200 --> 00:30:29,230
intensively at the moment have been

699
00:30:32,940 --> 00:30:31,210
methanogenesis and sulfate reduction

700
00:30:35,910 --> 00:30:32,950
both of which we can demonstrate

701
00:30:38,580 --> 00:30:35,920
happening within the rate rock matrix at

702
00:30:40,460 --> 00:30:38,590
depth and today and tomorrow I'll give a

703
00:30:42,630 --> 00:30:40,470
talk that will sort of speak more

704
00:30:43,950 --> 00:30:42,640
holistically about our findings at the

705
00:30:46,080 --> 00:30:43,960
moment again I'm just staying on the

706
00:30:48,300 --> 00:30:46,090
methane theme

707
00:30:49,980 --> 00:30:48,310
what's been exciting is if we can go

708
00:30:51,720 --> 00:30:49,990
down and extract methane out of these

709
00:30:54,630 --> 00:30:51,730
environments and try and identify its

710
00:30:56,550 --> 00:30:54,640
origin source almost every geo chemical

711
00:30:59,400 --> 00:30:56,560
and biological parameter that we measure

712
00:31:00,570 --> 00:30:59,410
indicates that's biological origin so

713
00:31:02,940 --> 00:31:00,580

we're sitting again in these low

714
00:31:04,620 --> 00:31:02,950
temperature conditions stable isotope

715
00:31:06,090 --> 00:31:04,630
geochemistry has not been very useful to

716
00:31:09,810 --> 00:31:06,100
us this is a really carbon enriched

717
00:31:11,460 --> 00:31:09,820
system but isotopologues parameters and

718
00:31:13,440 --> 00:31:11,470
looking at kinetic bond disorder in the

719
00:31:14,640 --> 00:31:13,450
methane have been very instructive in

720
00:31:17,000 --> 00:31:14,650
terms of telling us something about

721
00:31:19,230 --> 00:31:17,010
biological production of methane

722
00:31:20,730 --> 00:31:19,240
Emily Krauss on Tuesday gave an

723
00:31:22,830 --> 00:31:20,740
excellent talk where which she's been

724
00:31:25,140 --> 00:31:22,840
looking at is the remarkable abundance

725
00:31:27,150 --> 00:31:25,150
of methanogens that are present in DNA

726
00:31:29,490 --> 00:31:27,160
extracted out of these subsurface fluids

727
00:31:31,500 --> 00:31:29,500
and being able to show transcription and

728
00:31:35,600 --> 00:31:31,510
activity in those same samples that's

729
00:31:37,830 --> 00:31:35,610
dominated by methanogenic organisms

730
00:31:41,340 --> 00:31:37,840
another paper just published this year

731
00:31:43,920 --> 00:31:41,350
by Libby phones also was probing the

732
00:31:45,870 --> 00:31:43,930
distribution of both antigenic activity

733
00:31:48,330 --> 00:31:45,880
across a diversity of chemical regimes

734
00:31:50,790 --> 00:31:48,340
we see in the subsurface and looking at

735
00:31:53,010 --> 00:31:50,800
the 14 carbon incorporation into methane

736
00:31:55,230 --> 00:31:53,020
through co2 reduction and into biomass

737
00:31:57,840 --> 00:31:55,240
because again show that even when we go

738
00:31:59,910 --> 00:31:57,850

to high pH conditions and loke co2

739
00:32:02,880 --> 00:31:59,920
availability that were able to see

740
00:32:05,250 --> 00:32:02,890
methane production proceeding the

741
00:32:06,750 --> 00:32:05,260
question is how and we need to

742
00:32:08,730 --> 00:32:06,760
understand a lot more about the

743
00:32:10,800 --> 00:32:08,740
physiology of organisms that really

744
00:32:12,720 --> 00:32:10,810
inhabit some of these environments

745
00:32:13,860 --> 00:32:12,730
especially when carbons not available to

746
00:32:16,830 --> 00:32:13,870
them and yet they're still able to

747
00:32:18,930 --> 00:32:16,840
slowly pump out methane we've been

748
00:32:20,610 --> 00:32:18,940
fortunate and part of the work in RPL

749
00:32:22,170 --> 00:32:20,620
that we were able to isolate this

750
00:32:24,300 --> 00:32:22,180
dominant methanogens we're finding

751
00:32:27,480 --> 00:32:24,310
broadly distributed on earth and these

752
00:32:29,910 --> 00:32:27,490
continental peridotite hosted aquifers

753
00:32:31,380 --> 00:32:29,920
this is a methane of Actium species it's

754
00:32:32,970 --> 00:32:31,390
being detected in all sorts of studies

755
00:32:35,370 --> 00:32:32,980
that are being published at the moment

756
00:32:36,900 --> 00:32:35,380
and typically we are study it under

757
00:32:41,370 --> 00:32:36,910
something that's more moderate in terms

758
00:32:43,290 --> 00:32:41,380
of the availability following on work

759
00:32:44,820 --> 00:32:43,300
that for example that Tim Crawley done

760
00:32:48,060 --> 00:32:44,830
looking at carbonate minerals as a

761
00:32:56,860 --> 00:32:48,070
potential way to do methanogenesis on

762
00:33:06,090 --> 00:32:59,890
sealed and even when you're above pH ten

763
00:33:10,560 --> 00:33:08,850

rocks and use that co2 to produce

764
00:33:12,510 --> 00:33:10,570
methane at very slow rates but

765
00:33:18,120 --> 00:33:12,520
persistent rates and with a biological

766
00:33:20,220 --> 00:33:18,130
signature that's in it okay in last

767
00:33:23,160 --> 00:33:20,230
slide of sort of conceptual data would

768
00:33:24,840 --> 00:33:23,170
be that what's been promising is that

769
00:33:26,400 --> 00:33:24,850
there's a lot of indicators from recent

770
00:33:28,530 --> 00:33:26,410
studies to that when you go into these

771
00:33:30,240 --> 00:33:28,540
carbonated hard rock systems the

772
00:33:32,460 --> 00:33:30,250
preservation potential for that both

773
00:33:34,920 --> 00:33:32,470
extant and fossil microbial communities

774
00:33:36,810 --> 00:33:34,930
is really high so it's helping us to

775
00:33:39,810 --> 00:33:36,820
again to develop the search strategy of

776
00:33:41,910 --> 00:33:39,820
where to look for these organisms so the

777
00:33:43,410 --> 00:33:41,920
key idea that I want to relate and

778
00:33:45,120 --> 00:33:43,420
translate back to thinking about where

779
00:33:47,010 --> 00:33:45,130
we're going to look or where you should

780
00:33:48,900 --> 00:33:47,020
be looking for this kind of slow

781
00:33:51,150 --> 00:33:48,910
methanogenic activity in the hard rock

782
00:33:53,430 --> 00:33:51,160
system on Mars is that we really are

783
00:33:55,200 --> 00:33:53,440
able to not only go into actively

784
00:33:57,720 --> 00:33:55,210
circulating groundwater systems but we

785
00:33:59,970 --> 00:33:57,730
can move to static ones so long as the

786
00:34:02,460 --> 00:33:59,980
rock was previously carbonated early in

787
00:34:04,290 --> 00:34:02,470
its history and we can have persistent

788
00:34:06,300 --> 00:34:04,300

methane production storage and

789
00:34:07,980 --> 00:34:06,310
subsequent release and these long

790
00:34:09,419 --> 00:34:07,990
residence times fluids and I think

791
00:34:11,880 --> 00:34:09,429
that's really promising for starting to

792
00:34:13,530 --> 00:34:11,890
consider some of the interactions

793
00:34:16,550 --> 00:34:13,540
between the subsurface and the shallow

794
00:34:20,820 --> 00:34:16,560
surface environment Thanks

795
00:34:23,169 --> 00:34:20,830
[Music]

796
00:34:24,590 --> 00:34:23,179
[Applause]

797
00:34:26,389 --> 00:34:24,600
thank you

798
00:34:28,730 --> 00:34:26,399
I'm Barbara Sherwood Lawler from the

799
00:34:30,020 --> 00:34:28,740
University of Toronto and as soon as the

800
00:34:32,210 --> 00:34:30,030
slides come up you'll note that I have

801
00:34:34,340 --> 00:34:32,220
skipped the title slide because in some

802
00:34:36,350 --> 00:34:34,350
ways what I'm about to do is a kind of

803
00:34:37,880 --> 00:34:36,360
an a continuation of the beautiful setup

804
00:34:40,310 --> 00:34:37,890
that Alexis did in terms of these

805
00:34:42,800 --> 00:34:40,320
terrestrial analogues but in our case

806
00:34:45,710 --> 00:34:42,810
I'm going to take us back in time and

807
00:34:46,970 --> 00:34:45,720
deeper in depth and particularly

808
00:34:48,680 --> 00:34:46,980
focusing on some of the information

809
00:34:51,700 --> 00:34:48,690
that's relevant to Mars and other

810
00:34:55,520 --> 00:34:51,710
astrobiology targets related to the

811
00:34:57,230 --> 00:34:55,530
Precambrian rocks of the planet Mars

812
00:34:59,920 --> 00:34:57,240
isn't the only planet that we need to go

813
00:35:02,660 --> 00:34:59,930

to to take a look at ancient rock

814
00:35:04,400 --> 00:35:02,670
sometimes it flies under the radar a bit

815
00:35:07,660 --> 00:35:04,410
unless you happen to be Canadian and

816
00:35:10,490 --> 00:35:07,670
live on these rocks or Australian but

817
00:35:13,070 --> 00:35:10,500
72% of the continental crust by surface

818
00:35:15,020 --> 00:35:13,080
area is Precambrian an age now of course

819
00:35:16,880 --> 00:35:15,030
it's not as old is not as much that's

820
00:35:20,150 --> 00:35:16,890
preserved as old as Mars but nonetheless

821
00:35:23,270 --> 00:35:20,160
of that 72 percent 14 percent is arcane

822
00:35:25,640 --> 00:35:23,280
and aged mostly between 2.7 and 3

823
00:35:28,160 --> 00:35:25,650
billion years that's a lot of real

824
00:35:30,230 --> 00:35:28,170
estate and the beauty of it is it allows

825
00:35:31,730 --> 00:35:30,240
us to take a look on this planet at

826
00:35:34,430 --> 00:35:31,740
analog systems that can give us

827
00:35:37,040 --> 00:35:34,440
information about these kinds of organic

828
00:35:39,910 --> 00:35:37,050
factories that Jen referred to and the

829
00:35:41,660 --> 00:35:39,920
kinds of processes and balance between

830
00:35:44,540 --> 00:35:41,670
microbiology and places where we see

831
00:35:46,550 --> 00:35:44,550
active microbial populations and other

832
00:35:49,870 --> 00:35:46,560
places where we see in fact dominance of

833
00:35:52,670 --> 00:35:49,880
more abiotic Lea driven organic

834
00:35:54,020 --> 00:35:52,680
synthesis in the deep subsurface so

835
00:35:55,730 --> 00:35:54,030
really that's what I'll be focusing on

836
00:35:58,220 --> 00:35:55,740
here is a little bit talking about why

837
00:35:59,780 --> 00:35:58,230
it is these deep fracture systems that

838
00:36:02,360 --> 00:35:59,790

we investigate right from surface on

839
00:36:03,830 --> 00:36:02,370
down to three and four kilometers why

840
00:36:05,540 --> 00:36:03,840
they're particularly important as we

841
00:36:07,820 --> 00:36:05,550
think about the exploration of a

842
00:36:10,520 --> 00:36:07,830
habitability and potential bio

843
00:36:12,800 --> 00:36:10,530
signatures for Mars these are fractured

844
00:36:15,650 --> 00:36:12,810
control systems they sustain

845
00:36:18,020 --> 00:36:15,660
habitability and energy gradients a very

846
00:36:21,650 --> 00:36:18,030
hydrogen rich on the order of Millie

847
00:36:23,870 --> 00:36:21,660
moles and methane rich and they also

848
00:36:26,510 --> 00:36:23,880
contain abundant organics such as ethane

849
00:36:29,330 --> 00:36:26,520
propane and some of the small molecular

850
00:36:32,570 --> 00:36:29,340
weight volatile fatty acids like acetate

851
00:36:34,370 --> 00:36:32,580
and lactate one of the other important

852
00:36:34,910 --> 00:36:34,380
reasons to take a look at these systems

853
00:36:37,069 --> 00:36:34,920
is

854
00:36:40,130 --> 00:36:37,079
that because the major periods of

855
00:36:42,710 --> 00:36:40,140
ultramafic production on our planet or

856
00:36:44,299 --> 00:36:42,720
in the Archaean if we're particularly

857
00:36:46,280 --> 00:36:44,309
interested in some of the processes that

858
00:36:48,200 --> 00:36:46,290
alexis was pointing out around the

859
00:36:50,210 --> 00:36:48,210
production of hydrogen and electron

860
00:36:52,609 --> 00:36:50,220
donors and acceptors related to

861
00:36:54,680 --> 00:36:52,619
serpentinization and ultramafic rock

862
00:36:57,430 --> 00:36:54,690
that it behooves us to take a look at

863
00:37:00,470 --> 00:36:57,440

these these are the largest exposures of

864
00:37:02,660 --> 00:37:00,480
billion-year-old ultramafic rock on the

865
00:37:03,950 --> 00:37:02,670
entire planet and with direct relevance

866
00:37:06,799 --> 00:37:03,960
then to the investigation of these

867
00:37:08,960 --> 00:37:06,809
processes for Mars as alexis mentioned

868
00:37:10,670 --> 00:37:08,970
these are low temperature systems within

869
00:37:13,160 --> 00:37:10,680
these systems we see typically less than

870
00:37:14,960 --> 00:37:13,170
a hundred degrees Celsius and yet

871
00:37:16,670 --> 00:37:14,970
abundant production of hydrogen be a

872
00:37:18,829 --> 00:37:16,680
radial assistance of Penton ization

873
00:37:21,079 --> 00:37:18,839
depending on where we are and as I

874
00:37:24,349 --> 00:37:21,089
mentioned abiotic organic synthesis as

875
00:37:26,120 --> 00:37:24,359
well the key or one of the key reasons

876
00:37:28,010 --> 00:37:26,130
to take a look at these systems in

877
00:37:30,170 --> 00:37:28,020
addition to other earth analogs is

878
00:37:33,740 --> 00:37:30,180
because they do allow us that capacity

879
00:37:36,559 --> 00:37:33,750
to not only look at active reactions

880
00:37:39,260 --> 00:37:36,569
because indeed as Jen pointed out these

881
00:37:42,289 --> 00:37:39,270
are places where the carbon cycle and

882
00:37:43,880 --> 00:37:42,299
reactions are still taking place but

883
00:37:45,740 --> 00:37:43,890
nonetheless because of the very low

884
00:37:47,660 --> 00:37:45,750
temperatures these are more sluggish

885
00:37:51,200 --> 00:37:47,670
rates of reaction so we have both

886
00:37:53,240 --> 00:37:51,210
reactivity but also preservation in the

887
00:37:54,620 --> 00:37:53,250
subsurface and in particular because

888
00:37:56,720 --> 00:37:54,630

they are deep because they are in

889
00:37:59,089 --> 00:37:56,730
fractures in some of these fluids we see

890
00:38:00,530 --> 00:37:59,099
preservation of the products of

891
00:38:03,130 --> 00:38:00,540
processes that may have been going on

892
00:38:05,870 --> 00:38:03,140
for millions or even billions of years

893
00:38:07,970 --> 00:38:05,880
another advantage of these is as we get

894
00:38:10,039 --> 00:38:07,980
deeper it allows us to take a look at

895
00:38:12,410 --> 00:38:10,049
another spectrum of sites particularly

896
00:38:15,349 --> 00:38:12,420
down below two and three kilometers we

897
00:38:17,089 --> 00:38:15,359
have a handful of sites where we do see

898
00:38:19,190 --> 00:38:17,099
life but it seems to be life that's

899
00:38:22,309 --> 00:38:19,200
present within systems that are still

900
00:38:24,950 --> 00:38:22,319
primarily dominated by abiotic processes

901
00:38:27,470 --> 00:38:24,960
so it provides us another step further

902
00:38:30,470 --> 00:38:27,480
on that spectrum that alexis laid out an

903
00:38:32,089 --> 00:38:30,480
ability to look at subsurface processes

904
00:38:34,640 --> 00:38:32,099
where there's abundant methanogenesis

905
00:38:36,250 --> 00:38:34,650
and sulfate reduction going on all the

906
00:38:38,839 --> 00:38:36,260
way down to systems in which

907
00:38:41,510 --> 00:38:38,849
microbiology may still be there but it's

908
00:38:43,730 --> 00:38:41,520
just turning over very very slowly in a

909
00:38:46,730 --> 00:38:43,740
system that's still dominated by abiotic

910
00:38:48,140 --> 00:38:46,740
reactions and in that case might once

911
00:38:50,600 --> 00:38:48,150
again be something that my

912
00:38:52,700 --> 00:38:50,610
be a closer analog to the types of

913
00:38:54,890 --> 00:38:52,710

things we'd be looking at on Mars where

914
00:38:57,680 --> 00:38:54,900
if there was any life or is any life it

915
00:39:00,830 --> 00:38:57,690
may be a tiny baseline blip up over a

916
00:39:03,620 --> 00:39:00,840
largely abiotic baseline and then

917
00:39:06,320 --> 00:39:03,630
finally of course because the plates of

918
00:39:08,780 --> 00:39:06,330
our planet the cratons are technically

919
00:39:10,910 --> 00:39:08,790
quiescent they provide us with also an

920
00:39:14,090 --> 00:39:10,920
analogy to take a look at something's

921
00:39:16,850 --> 00:39:14,100
more similar to a single plate planet

922
00:39:18,650 --> 00:39:16,860
like Mars or preservation of fluids and

923
00:39:23,150 --> 00:39:18,660
potentially bio signatures may take

924
00:39:24,260 --> 00:39:23,160
place on planetary timescales these are

925
00:39:25,640 --> 00:39:24,270
some of the papers that you can take a

926
00:39:26,930 --> 00:39:25,650
look at if you're not familiar with this

927
00:39:28,990 --> 00:39:26,940
work and want to take a look at the

928
00:39:31,010 --> 00:39:29,000
details again one of the key things is

929
00:39:33,350 --> 00:39:31,020
findings from this has been an

930
00:39:37,070 --> 00:39:33,360
understanding that there are habitable

931
00:39:39,920 --> 00:39:37,080
environments 2 3 4 kilometres down in

932
00:39:41,510 --> 00:39:39,930
billion-year-old rock or the products of

933
00:39:44,810 --> 00:39:41,520
those reactions and the products of

934
00:39:47,240 --> 00:39:44,820
those in some cases microbial population

935
00:39:49,810 --> 00:39:47,250
of those systems are preserved on global

936
00:39:52,460 --> 00:39:49,820
and geologic timescales

937
00:39:54,290 --> 00:39:52,470
but with the renewed interest on methane

938
00:39:56,150 --> 00:39:54,300

on Mars I thought I'd take a couple of

939
00:39:58,760 --> 00:39:56,160
moments to just point out that some of

940
00:40:00,710 --> 00:39:58,770
the key connections to that finding and

941
00:40:02,360 --> 00:40:00,720
because one of the questions I often get

942
00:40:03,950 --> 00:40:02,370
asked is why do we care about something

943
00:40:05,510 --> 00:40:03,960
that's happening two kilometers down

944
00:40:07,400 --> 00:40:05,520
what's the relevance of that to the

945
00:40:09,530 --> 00:40:07,410
surface of Earth let alone the surface

946
00:40:11,240 --> 00:40:09,540
of Mars so one of the things that

947
00:40:13,370 --> 00:40:11,250
important to emphasize is that there are

948
00:40:16,040 --> 00:40:13,380
indeed conduits to the surface for these

949
00:40:17,240 --> 00:40:16,050
systems we typically do go down to take

950
00:40:18,710 --> 00:40:17,250
a look at them but there are many other

951
00:40:20,540 --> 00:40:18,720
places where we can look at them from

952
00:40:22,520 --> 00:40:20,550
the surface there are places where

953
00:40:25,580 --> 00:40:22,530
diffuse gas over the cratons

954
00:40:27,050 --> 00:40:25,590
is really being released this is from an

955
00:40:29,630 --> 00:40:27,060
ultra mafic rock in northern ontario

956
00:40:32,030 --> 00:40:29,640
that's only about two to three meters

957
00:40:34,190 --> 00:40:32,040
below surface in a small boring we put

958
00:40:35,450 --> 00:40:34,200
into an ultramafic rock and what you're

959
00:40:37,460 --> 00:40:35,460
seeing there is the discharge of

960
00:40:38,660 --> 00:40:37,470
something that's about 30% hydrogen and

961
00:40:41,630 --> 00:40:38,670
60% methane

962
00:40:42,980 --> 00:40:41,640
very much within reach of the surface I

963
00:40:46,070 --> 00:40:42,990

think Jen referred to the fact that in

964
00:40:47,960 --> 00:40:46,080
some cases that redox transition happens

965
00:40:49,100 --> 00:40:47,970
more quickly than we expect and then

966
00:40:50,930 --> 00:40:49,110
these are pictures of some of the

967
00:40:53,090 --> 00:40:50,940
perennial Springs in the High Arctic or

968
00:40:54,530 --> 00:40:53,100
once again fracture controlled movement

969
00:40:57,200 --> 00:40:54,540
of ground water coming through the

970
00:40:58,550 --> 00:40:57,210
permafrost on a permanent basis shows us

971
00:41:01,640 --> 00:40:58,560
that some of these sub surface processes

972
00:41:03,559 --> 00:41:01,650
indeed can come to the atmosphere

973
00:41:06,440 --> 00:41:03,569
close then just by reminding people in

974
00:41:08,990 --> 00:41:06,450
the context of some of this work of the

975
00:41:11,029 --> 00:41:09,000
astrobiology strategy that was done last

976
00:41:12,529 --> 00:41:11,039
year rather than talk just about our own

977
00:41:14,089 --> 00:41:12,539
work I wanted to place some of the

978
00:41:16,609 --> 00:41:14,099
things I've just said in the context of

979
00:41:18,920 --> 00:41:16,619
that strategy there were a number of key

980
00:41:20,809 --> 00:41:18,930
take-home messages within the strategy

981
00:41:23,750 --> 00:41:20,819
one of them referring to this idea of

982
00:41:26,210 --> 00:41:23,760
the reminding us all to go abroad when

983
00:41:28,309 --> 00:41:26,220
we think about the investigation of life

984
00:41:30,650 --> 00:41:28,319
and so I think what we've seen today

985
00:41:32,420 --> 00:41:30,660
across the board in the panel's talks is

986
00:41:34,549 --> 00:41:32,430
something that reflects that indeed a

987
00:41:37,250 --> 00:41:34,559
focus on the idea that as we look at

988
00:41:39,019 --> 00:41:37,260

biomarkers or signs of past life we want

989
00:41:40,730 --> 00:41:39,029
to definitely focus on rock-types

990
00:41:42,829 --> 00:41:40,740
or electron donors and electron

991
00:41:46,039 --> 00:41:42,839
acceptors may have supported or continue

992
00:41:48,200 --> 00:41:46,049
to support chemo with atrophic life and

993
00:41:49,910 --> 00:41:48,210
thinking about the kinds of biomarkers

994
00:41:52,700 --> 00:41:49,920
that might tell us something about rock

995
00:41:55,039 --> 00:41:52,710
hosted life is clearly an important part

996
00:41:57,650 --> 00:41:55,049
of that strategy and then finally just

997
00:41:59,960 --> 00:41:57,660
to wrap up with my very last slide the

998
00:42:02,180 --> 00:41:59,970
issue as well one of the main take-home

999
00:42:04,609 --> 00:42:02,190
messages of that report was the idea of

1000
00:42:06,890 --> 00:42:04,619
going deep talking about the necessity

1001
00:42:09,049 --> 00:42:06,900
of understanding subsurface processes

1002
00:42:11,120 --> 00:42:09,059
and subsurface environments for life and

1003
00:42:13,069 --> 00:42:11,130
indeed the report made I think a couple

1004
00:42:14,450 --> 00:42:13,079
of important points that drilling

1005
00:42:16,819 --> 00:42:14,460
technologies of course extremely

1006
00:42:19,609 --> 00:42:16,829
important the ExoMars and other drilling

1007
00:42:21,200 --> 00:42:19,619
development but also indicating that of

1008
00:42:23,809 --> 00:42:21,210
course as we've seen reflected here

1009
00:42:26,260 --> 00:42:23,819
today understanding the subsurface can

1010
00:42:28,329 --> 00:42:26,270
in fact involve a wide variety of

1011
00:42:31,069 --> 00:42:28,339
investigations in addition to drilling

1012
00:42:33,200 --> 00:42:31,079
geophysical methods such as probes the

1013
00:42:34,519 --> 00:42:33,210

insight Lander for instance the

1014
00:42:36,769 --> 00:42:34,529
investigation of geomorphological

1015
00:42:39,500 --> 00:42:36,779
features and just to end where Manuel

1016
00:42:42,710 --> 00:42:39,510
started us this idea that subsurface

1017
00:42:44,359 --> 00:42:42,720
processes impact atmospheres and so that

1018
00:42:46,309 --> 00:42:44,369
in fact that conversation that's

1019
00:42:47,839 --> 00:42:46,319
developing between astrobiology and

1020
00:42:49,910 --> 00:42:47,849
subsurface scientists and those

1021
00:42:51,799 --> 00:42:49,920
investigate the atmospheres is going to

1022
00:42:54,019 --> 00:42:51,809
be important not only for understanding

1023
00:42:56,110 --> 00:42:54,029
Mars but understanding the search for

1024
00:43:11,830 --> 00:42:56,120
life

1025
00:43:17,180 --> 00:43:15,470
great well good morning everyone I'm Ken

1026
00:43:19,280 --> 00:43:17,190
Willeford from the Jet Propulsion

1027
00:43:23,690 --> 00:43:19,290
Laboratory I'm an organic and isotope

1028
00:43:28,520 --> 00:43:23,700
geochemistry project scientist for Mars

1029
00:43:29,480 --> 00:43:28,530
2020 Rover mission Bethenny when she

1030
00:43:32,480 --> 00:43:29,490
asked me to be part of this panel

1031
00:43:35,360 --> 00:43:32,490
suggested I say something about lessons

1032
00:43:37,970 --> 00:43:35,370
from early Earth at Mars 2020 I've stuck

1033
00:43:39,590 --> 00:43:37,980
Mars sample return in there because in

1034
00:43:42,740 --> 00:43:39,600
part that's the lesson from early Earth

1035
00:43:46,550 --> 00:43:42,750
which we'll get to in a moment but just

1036
00:43:49,430 --> 00:43:46,560
to begin with a few lessons from early

1037
00:43:52,970 --> 00:43:49,440
Earth these are not self-evident truths

1038
00:43:55,660 --> 00:43:52,980

these are lessons that I take personally

1039
00:43:59,780 --> 00:43:55,670
from early Earth but I think they're

1040
00:44:03,530 --> 00:43:59,790
they're valid actually before we get to

1041
00:44:05,390 --> 00:44:03,540
that one I just want to point out what

1042
00:44:07,850 --> 00:44:05,400
you're looking at here you're seeing a

1043
00:44:09,800 --> 00:44:07,860
slide of the I'll go back so we're not

1044
00:44:13,370 --> 00:44:09,810
confused by the lesson so you're seeing

1045
00:44:16,160 --> 00:44:13,380
a microscope slide sitting on a

1046
00:44:20,120 --> 00:44:16,170
microscope with transmitted light going

1047
00:44:22,670 --> 00:44:20,130
going through it and this is a sample of

1048
00:44:25,700 --> 00:44:22,680
the gunflint formation about two billion

1049
00:44:28,430 --> 00:44:25,710
years old 1.9 billion years old and

1050
00:44:31,520 --> 00:44:28,440
there's an arrow there pointing to a

1051
00:44:33,410 --> 00:44:31,530
filament that you can tell once it comes

1052
00:44:38,360 --> 00:44:33,420
into focus it has a sense of being

1053
00:44:41,060 --> 00:44:38,370
hollow it it's brown the brown is

1054
00:44:42,560 --> 00:44:41,070
organic matter a type of organic matter

1055
00:44:44,060 --> 00:44:42,570
that the Jen talked about this is

1056
00:44:47,810 --> 00:44:44,070
karagin it's a 2 billion year old

1057
00:44:49,940 --> 00:44:47,820
karagin organized into what is I would

1058
00:44:51,440 --> 00:44:49,950
call a very biologically suggestive

1059
00:44:55,310 --> 00:44:51,450
morphology but it's a very simple

1060
00:44:57,170 --> 00:44:55,320
morphology right it's a simple tube but

1061
00:44:59,840 --> 00:44:57,180
it does you know look like an organism

1062
00:45:01,850 --> 00:44:59,850
and then around that filament you see

1063
00:45:03,230 --> 00:45:01,860

lots of other little blebs and blobs of

1064
00:45:05,990 --> 00:45:03,240
carriage and organized into different

1065
00:45:08,270 --> 00:45:06,000
shapes that are variably informative or

1066
00:45:10,430 --> 00:45:08,280
not some of them we think are probably

1067
00:45:12,710 --> 00:45:10,440
broken up little bits of organic matter

1068
00:45:15,400 --> 00:45:12,720
some of them there's one up by the N in

1069
00:45:19,190 --> 00:45:15,410
lessons if you watch that come into

1070
00:45:22,550 --> 00:45:19,200
in a second here it has it's a little

1071
00:45:25,460 --> 00:45:22,560
blob with with tiny little you know sub

1072
00:45:27,440 --> 00:45:25,470
filaments coming off of it so that is

1073
00:45:31,940 --> 00:45:27,450
potentially a different kind of organism

1074
00:45:34,450 --> 00:45:31,950
anyway this is this is in some case the

1075
00:45:37,520 --> 00:45:34,460
the some of the best examples the most

1076
00:45:39,860 --> 00:45:37,530
obvious examples of Precambrian life on

1077
00:45:41,660 --> 00:45:39,870
earth and and in fact this example is

1078
00:45:45,140 --> 00:45:41,670
one of the first examples of Precambrian

1079
00:45:46,700 --> 00:45:45,150
life on earth to ever be discovered back

1080
00:45:48,920 --> 00:45:46,710
in the 1950s so what are the lessons

1081
00:45:52,310 --> 00:45:48,930
signs of any ancient Mars life are

1082
00:45:55,130 --> 00:45:52,320
likely to be small rare and cryptic ok

1083
00:45:57,350 --> 00:45:55,140
so life on on ancient Mars we believe

1084
00:45:59,300 --> 00:45:57,360
was completely microbial without free

1085
00:46:01,250 --> 00:45:59,310
oxygen you don't get very large as an

1086
00:46:05,920 --> 00:46:01,260
organism and so you're likely to be

1087
00:46:08,240 --> 00:46:05,930
small like this or micron scale but

1088
00:46:09,950 --> 00:46:08,250

there are exceptions so these small

1089
00:46:11,900 --> 00:46:09,960
things can organize into communities

1090
00:46:13,280 --> 00:46:11,910
into microbial mats that can get large

1091
00:46:15,980 --> 00:46:13,290
and macroscopic things like

1092
00:46:17,990 --> 00:46:15,990
stromatolites and we may indeed expect

1093
00:46:19,910 --> 00:46:18,000
to find things like stromatolites but

1094
00:46:23,030 --> 00:46:19,920
these things on early Earth are rare

1095
00:46:25,820 --> 00:46:23,040
they exist but they're rare and the

1096
00:46:28,010 --> 00:46:25,830
rarity of signs of life depends in part

1097
00:46:29,420 --> 00:46:28,020
on what type of habitat we're looking at

1098
00:46:31,670 --> 00:46:29,430
we've we've heard about lots of

1099
00:46:33,500 --> 00:46:31,680
different types of habitats bio

1100
00:46:35,300 --> 00:46:33,510
signatures are more or less rare in

1101
00:46:37,250 --> 00:46:35,310
different kinds of habitats and then

1102
00:46:38,870 --> 00:46:37,260
their cryptic they're not only hard to

1103
00:46:40,850 --> 00:46:38,880
find but they can be very difficult to

1104
00:46:42,410 --> 00:46:40,860
understand and very difficult to gain

1105
00:46:45,950 --> 00:46:42,420
confidence for us to gain confidence

1106
00:46:47,600 --> 00:46:45,960
that they are indeed biological context

1107
00:46:49,280 --> 00:46:47,610
is absolutely critical so that's what

1108
00:46:51,500 --> 00:46:49,290
we're working on with Mars 2020 is to

1109
00:46:53,020 --> 00:46:51,510
establish that context so the second

1110
00:46:55,760 --> 00:46:53,030
lesson here based on all that

1111
00:46:58,610 --> 00:46:55,770
satisfactory confirmation of biogenesis

1112
00:47:01,130 --> 00:46:58,620
II that is our ability as a scientific

1113
00:47:03,350 --> 00:47:01,140

community to conclude confidently that

1114
00:47:06,740 --> 00:47:03,360
evidence we've found in in old rocks on

1115
00:47:08,390 --> 00:47:06,750
Mars clearly came from life on Mars will

1116
00:47:10,250 --> 00:47:08,400
likely require the most powerful

1117
00:47:12,410 --> 00:47:10,260
analytical techniques available on earth

1118
00:47:15,590 --> 00:47:12,420
so this leads us to the second point

1119
00:47:17,300 --> 00:47:15,600
which is Mars sample return so in

1120
00:47:19,160 --> 00:47:17,310
preparing for a conference on Mars

1121
00:47:21,110 --> 00:47:19,170
sample return last year I went to giving

1122
00:47:24,200 --> 00:47:21,120
around the JPL archives to try to find

1123
00:47:26,000 --> 00:47:24,210
the oldest reference sort of official

1124
00:47:27,980 --> 00:47:26,010
reference to Mars sample return in the

1125
00:47:30,830 --> 00:47:27,990
JPL archives and came up with this with

1126
00:47:33,650 --> 00:47:30,840
friend Mickey the JPL librarian dug this

1127
00:47:36,230 --> 00:47:33,660
out for me from 1984 a study on Mars

1128
00:47:37,790 --> 00:47:36,240
sample return where the architecture is

1129
00:47:39,320 --> 00:47:37,800
shown pretty obviously here you have a

1130
00:47:41,000 --> 00:47:39,330
little Rover he needs something to go

1131
00:47:44,000 --> 00:47:41,010
out and get samples way before a Mars

1132
00:47:45,170 --> 00:47:44,010
rover ever actually existed it has a few

1133
00:47:47,330 --> 00:47:45,180
scientific instruments some

1134
00:47:48,890 --> 00:47:47,340
communication capability there and then

1135
00:47:52,700 --> 00:47:48,900
you have a lander and the lander has a

1136
00:47:54,530 --> 00:47:52,710
rocket on it in the in the rocket near

1137
00:47:56,120 --> 00:47:54,540
the top you see a sphere I think that

1138
00:47:58,940 --> 00:47:56,130

sphere is probably what we now call the

1139
00:48:00,500 --> 00:47:58,950
orbiting sample because that rocket

1140
00:48:02,870 --> 00:48:00,510
launches the samples collected by the

1141
00:48:04,370 --> 00:48:02,880
rover into orbit and they're in the top

1142
00:48:05,960 --> 00:48:04,380
of the image you see an orbiter which

1143
00:48:07,820 --> 00:48:05,970
does communications for the other

1144
00:48:09,560 --> 00:48:07,830
missions but also rendezvous is what

1145
00:48:12,350 --> 00:48:09,570
those samples eventually brings them

1146
00:48:15,320 --> 00:48:12,360
back to earth so here we are 35 years

1147
00:48:18,350 --> 00:48:15,330
after this and we're in the the wrap-up

1148
00:48:21,590 --> 00:48:18,360
stage of a study jointly between NASA

1149
00:48:23,060 --> 00:48:21,600
and ISA to put together an architecture

1150
00:48:26,000 --> 00:48:23,070
from our sample return that would be a

1151
00:48:29,990 --> 00:48:26,010
cooperative effort campaign of three

1152
00:48:34,340 --> 00:48:30,000
missions and sorry two additional

1153
00:48:37,880 --> 00:48:34,350
missions beyond Mars 2020 and it's not

1154
00:48:39,620 --> 00:48:37,890
official yet but it takes a lot of as

1155
00:48:41,330 --> 00:48:39,630
you can see a lot of persistence this

1156
00:48:43,340 --> 00:48:41,340
idea has been around for a long time a

1157
00:48:45,770 --> 00:48:43,350
lot of persistence a lot of patience a

1158
00:48:48,200 --> 00:48:45,780
lot of you know probably cooperation and

1159
00:48:50,420 --> 00:48:48,210
compromise to get this done in a

1160
00:48:52,840 --> 00:48:50,430
partnership between these two big space

1161
00:48:56,780 --> 00:48:52,850
agencies so let's hope for the best for

1162
00:48:58,430 --> 00:48:56,790
that but right now we're at you know

1163
00:49:00,980 --> 00:48:58,440

we're putting together Mars 2020 the

1164
00:49:02,780 --> 00:49:00,990
first part of that and it's it's really

1165
00:49:04,700 --> 00:49:02,790
starting to look like a rover in the in

1166
00:49:07,040 --> 00:49:04,710
the big cleanroom at JPL the spacecraft

1167
00:49:08,690 --> 00:49:07,050
assembly facility this is a recent

1168
00:49:11,930 --> 00:49:08,700
picture from I'd say a couple weeks ago

1169
00:49:14,359 --> 00:49:11,940
we have wheels now we have a mast you

1170
00:49:17,450 --> 00:49:14,369
can see the the wind sensors from Mehta

1171
00:49:19,640 --> 00:49:17,460
are on there on the mast and the arm was

1172
00:49:21,230 --> 00:49:19,650
recently installed so there's a webcam

1173
00:49:22,310 --> 00:49:21,240
where you can watch this live if you

1174
00:49:23,570 --> 00:49:22,320
haven't seen this yet and you're

1175
00:49:26,840 --> 00:49:23,580
interested in this sort of thing Google

1176
00:49:28,820 --> 00:49:26,850
JPL Mars 2020 webcam and you'll find a

1177
00:49:30,440 --> 00:49:28,830
live image of the cleanroom and see lots

1178
00:49:32,930 --> 00:49:30,450
of images like this of them putting it

1179
00:49:34,099 --> 00:49:32,940
together but just to very rapidly get

1180
00:49:36,020 --> 00:49:34,109
through this I know I'm running out of

1181
00:49:38,180 --> 00:49:36,030
time here we've got these four

1182
00:49:40,490 --> 00:49:38,190
objectives we're gonna land land on Mars

1183
00:49:41,660 --> 00:49:40,500
do basic geology try to understand how

1184
00:49:43,579 --> 00:49:41,670
did these rocks form and

1185
00:49:45,500 --> 00:49:43,589
where they altered will assess whether

1186
00:49:47,660 --> 00:49:45,510
the environment of deposition of these

1187
00:49:49,430 --> 00:49:47,670
rocks was habitable and then take the

1188
00:49:52,910 --> 00:49:49,440

next step and actually directly search

1189
00:49:54,770 --> 00:49:52,920
for signs of ancient life as we do that

1190
00:49:57,319 --> 00:49:54,780
we'll select locations that we think

1191
00:49:59,359 --> 00:49:57,329
offer the best potential to preserve not

1192
00:50:01,130 --> 00:49:59,369
only signs of ancient life but Mars

1193
00:50:02,990 --> 00:50:01,140
sample return is much bigger than

1194
00:50:05,030 --> 00:50:03,000
astrobiology astrobiology a very

1195
00:50:06,710 --> 00:50:05,040
exciting motivation for sample return

1196
00:50:10,069 --> 00:50:06,720
but we really want to understand how the

1197
00:50:12,079 --> 00:50:10,079
planet Mars evolved as a broader system

1198
00:50:14,359 --> 00:50:12,089
so signs of planetary evolution as well

1199
00:50:16,579 --> 00:50:14,369
and then everything we do we do with an

1200
00:50:20,390 --> 00:50:16,589
eye toward enabling future human and

1201
00:50:22,069 --> 00:50:20,400
robotic exploration we have this payload

1202
00:50:24,559 --> 00:50:22,079
I won't go through through this but

1203
00:50:27,049 --> 00:50:24,569
check out our website for all of our you

1204
00:50:28,910 --> 00:50:27,059
know fantastic capabilities we have we

1205
00:50:30,559 --> 00:50:28,920
have new engineering cameras will be

1206
00:50:33,549 --> 00:50:30,569
taking color images with our engineering

1207
00:50:35,660 --> 00:50:33,559
cameras stereozoom cameras on mass cam Z

1208
00:50:37,789 --> 00:50:35,670
we've got a ground-penetrating radar

1209
00:50:39,799 --> 00:50:37,799
looking beneath the surface of Mars for

1210
00:50:43,400 --> 00:50:39,809
the first time from the surface of Mars

1211
00:50:45,200 --> 00:50:43,410
and then an advanced instrument for

1212
00:50:47,539 --> 00:50:45,210
remote geochemistry remote spectroscopy

1213
00:50:49,460 --> 00:50:47,549

up on the mast in super cam and then

1214
00:50:51,950 --> 00:50:49,470
pixel and Sherlock which are two

1215
00:50:54,260 --> 00:50:51,960
instruments out on the turret which are

1216
00:50:55,819 --> 00:50:54,270
mapping instruments and the selection of

1217
00:50:58,970 --> 00:50:55,829
these instruments I believe follows on a

1218
00:51:01,099 --> 00:50:58,980
community trend in in the search for the

1219
00:51:03,349 --> 00:51:01,109
the most ancient evidence for life on

1220
00:51:05,089 --> 00:51:03,359
Earth and a reliance on spatially

1221
00:51:08,599 --> 00:51:05,099
resolved analysis and mapping

1222
00:51:11,030 --> 00:51:08,609
instruments to find these small rare bio

1223
00:51:13,280 --> 00:51:11,040
signatures and understand them given

1224
00:51:15,680 --> 00:51:13,290
their cryptic context and so pixel will

1225
00:51:18,200 --> 00:51:15,690
map the elemental composition at a scale

1226
00:51:20,089 --> 00:51:18,210
of a hundred microns over a couple

1227
00:51:23,059 --> 00:51:20,099
square centimeters and Sherlock is a

1228
00:51:25,400 --> 00:51:23,069
deep UV Raman and fluorescence mapper to

1229
00:51:28,010 --> 00:51:25,410
with a capability to detect and classify

1230
00:51:30,920 --> 00:51:28,020
organic molecules so the last thing I'll

1231
00:51:32,660 --> 00:51:30,930
say here is to give you a little bit of

1232
00:51:34,730 --> 00:51:32,670
a zoomed out image of our landing area

1233
00:51:37,720 --> 00:51:34,740
so this is jezero crater you see you're

1234
00:51:40,789 --> 00:51:37,730
here but put in its regional context and

1235
00:51:41,900 --> 00:51:40,799
if you were paying attention over the

1236
00:51:44,630 --> 00:51:41,910
last several years we have this

1237
00:51:46,430 --> 00:51:44,640
incredible four-year conversation and a

1238
00:51:48,289 --> 00:51:46,440

bunch of the people on this stage and

1239
00:51:50,359 --> 00:51:48,299
others in this room were or leaders and

1240
00:51:52,160 --> 00:51:50,369
participants in that conversation where

1241
00:51:53,550 --> 00:51:52,170
we evaluated these different possible

1242
00:51:56,130 --> 00:51:53,560
habitats on Mars

1243
00:51:58,740 --> 00:51:56,140
and it really came down at the end to I

1244
00:52:00,210 --> 00:51:58,750
would say these top two as the leaders

1245
00:52:04,290 --> 00:52:00,220
and kind of the end members of this

1246
00:52:05,850 --> 00:52:04,300
surface versus subsurface debate and and

1247
00:52:09,060 --> 00:52:05,860
I think it's it's led us to a mission

1248
00:52:11,780 --> 00:52:09,070
concept that is much richer than it

1249
00:52:14,370 --> 00:52:11,790
otherwise would have been where we have

1250
00:52:17,670 --> 00:52:14,380
so starting with Northeast syrtis down

1251
00:52:19,470 --> 00:52:17,680
to the south they're jezero crater up to

1252
00:52:22,500 --> 00:52:19,480
the north we have this new ellipse

1253
00:52:26,250 --> 00:52:22,510
called Midway we asked the question how

1254
00:52:28,530 --> 00:52:26,260
far how close to the jezero crater site

1255
00:52:30,750 --> 00:52:28,540
could you push a safe landing ellipse

1256
00:52:32,760 --> 00:52:30,760
where a mission like Mars 2020 a

1257
00:52:34,820 --> 00:52:32,770
follow-on mission for sample return

1258
00:52:37,620 --> 00:52:34,830
could land safely given Mars 2020

1259
00:52:39,270 --> 00:52:37,630
landing capabilities how close could you

1260
00:52:41,790 --> 00:52:39,280
push it to Jezreel crater and still

1261
00:52:42,780 --> 00:52:41,800
access the kinds of subsurface habitats

1262
00:52:44,550 --> 00:52:42,790
that we were talking about with

1263
00:52:47,130 --> 00:52:44,560

Northeast Certus and so that's the

1264
00:52:50,040 --> 00:52:47,140
Midway ellipse and so this is our

1265
00:52:53,550 --> 00:52:50,050
mission concept we begin in the jezero

1266
00:52:55,620 --> 00:52:53,560
crater exploring and sampling a clearly

1267
00:52:58,380 --> 00:52:55,630
habitable surface habitat there a crater

1268
00:53:01,920 --> 00:52:58,390
lake but then we we step outside the box

1269
00:53:03,780 --> 00:53:01,930
as barb mentioned if the box is the

1270
00:53:05,730 --> 00:53:03,790
crater lake and we investigate the

1271
00:53:07,560 --> 00:53:05,740
crater rim possible impact generator

1272
00:53:09,930 --> 00:53:07,570
hydrothermal systems and then the

1273
00:53:12,290 --> 00:53:09,940
terrain outside where we have aqueous

1274
00:53:15,330 --> 00:53:12,300
lis altered potentially ultramafic rocks

1275
00:53:16,440 --> 00:53:15,340
and and diverse subsurface habitats so

1276
00:53:19,080 --> 00:53:16,450
that's that's where we're going with

1277
00:53:21,670 --> 00:53:19,090
2020 and what we're looking at for from

1278
00:53:25,880 --> 00:53:21,680
our sample return thank you

1279
00:53:33,510 --> 00:53:29,010
all right thank you to all the

1280
00:53:35,569 --> 00:53:33,520
presenters I left hell it can go

1281
00:53:38,099 --> 00:53:35,579
overtime because he was essentially the

1282
00:53:39,900 --> 00:53:38,109
the one that was focusing more of Mars

1283
00:53:43,140 --> 00:53:39,910
2020 which is part of the main goal of

1284
00:53:45,319 --> 00:53:43,150
the discussion as well also because we

1285
00:53:49,470 --> 00:53:45,329
have about 20 minutes left for questions

1286
00:53:53,490 --> 00:53:49,480
by or comments that should allow

1287
00:53:55,170 --> 00:53:53,500
possibly for at least four five at least

1288
00:54:00,780 --> 00:53:55,180

depending on how long the questions are

1289
00:54:02,549 --> 00:54:00,790
so please go ahead yeah hi I'm Mike Wong

1290
00:54:04,339 --> 00:54:02,559
from the University of Washington thanks

1291
00:54:07,049 --> 00:54:04,349
to the panel for a wonderful discussion

1292
00:54:09,900 --> 00:54:07,059
so we've heard a lot about our amazing

1293
00:54:11,460 --> 00:54:09,910
flagship Rovers you know robotic

1294
00:54:13,950 --> 00:54:11,470
geologists on mars robotic

1295
00:54:15,660 --> 00:54:13,960
astrobiologists soon and i'm wondering

1296
00:54:16,890 --> 00:54:15,670
because a couple of friends and I have

1297
00:54:19,859 --> 00:54:16,900
been contemplating a sort of orthogonal

1298
00:54:22,319 --> 00:54:19,869
approach to Mars planetary sciences

1299
00:54:24,270 --> 00:54:22,329
where in addition to sending our our big

1300
00:54:27,569 --> 00:54:24,280
multi-billion dollar Rovers we send a

1301
00:54:30,240 --> 00:54:27,579
lot of small like single experiment

1302
00:54:32,940 --> 00:54:30,250
almost disposable kind of CubeSat like

1303
00:54:35,339 --> 00:54:32,950
Landers to Mars to sort of get a global

1304
00:54:36,539 --> 00:54:35,349
coverage of maybe just one specific

1305
00:54:37,799 --> 00:54:36,549
property so for instance I'm an

1306
00:54:39,329 --> 00:54:37,809
atmospheric scientist that would really

1307
00:54:41,789 --> 00:54:39,339
love to know the trace gas distribution

1308
00:54:43,770 --> 00:54:41,799
at the surface of Mars all around Mars

1309
00:54:44,970 --> 00:54:43,780
this globe I can imagine that geologists

1310
00:54:47,309 --> 00:54:44,980
would also be very interested in sending

1311
00:54:49,289 --> 00:54:47,319
a lot of small drills to sort of assess

1312
00:54:51,630 --> 00:54:49,299
the redox state of the near subsurface

1313
00:54:52,740 --> 00:54:51,640

of Mars all around the globe and I was

1314
00:54:55,410 --> 00:54:52,750
just wondering if the panel thinks that

1315
00:54:58,049 --> 00:54:55,420
this is something that is worth pursuing

1316
00:55:00,839 --> 00:54:58,059
in the Mars program or maybe there are

1317
00:55:03,510 --> 00:55:00,849
even plans to do something like this so

1318
00:55:05,190 --> 00:55:03,520
I can take the answer or do you want to

1319
00:55:07,400 --> 00:55:05,200
take it everyone can give a very short

1320
00:55:14,339 --> 00:55:07,410
answer

1321
00:55:15,809 --> 00:55:14,349
yeah there are initiatives there are

1322
00:55:18,859 --> 00:55:15,819
lots of studies going on and there are

1323
00:55:21,650 --> 00:55:18,869
actual NASA calls for proposals

1324
00:55:26,789 --> 00:55:21,660
announcements of opportunities that do

1325
00:55:27,900 --> 00:55:26,799
enable those kinds of proposals I would

1326
00:55:29,640 --> 00:55:27,910
say that I think we're at a really

1327
00:55:31,890 --> 00:55:29,650
exciting juncture in the Mars program

1328
00:55:33,750 --> 00:55:31,900
where we're about to accomplish we think

1329
00:55:34,980 --> 00:55:33,760
the goal of the last 35 years but

1330
00:55:36,780 --> 00:55:34,990
there's also something fundamental

1331
00:55:38,260 --> 00:55:36,790
changing which is this architecture

1332
00:55:40,630 --> 00:55:38,270
enabled by small SATs in term

1333
00:55:42,400 --> 00:55:40,640
the ability to access the surface and I

1334
00:55:44,830 --> 00:55:42,410
think that dovetails very nicely with

1335
00:55:46,930 --> 00:55:44,840
the diversity of Mars that we've

1336
00:55:48,370 --> 00:55:46,940
discovered the diversity of questions

1337
00:55:49,870 --> 00:55:48,380
about the ancient record and then

1338
00:55:51,790 --> 00:55:49,880

questions about the modern records so I

1339
00:55:53,500 --> 00:55:51,800
hope that we can have a program in

1340
00:55:55,120 --> 00:55:53,510
parallel that I include some of these

1341
00:55:56,650 --> 00:55:55,130
smaller less expensive missions of

1342
00:55:58,720 --> 00:55:56,660
opportunities to figure out yeah are

1343
00:56:00,550 --> 00:55:58,730
these trace gases signs of biological

1344
00:56:02,740 --> 00:56:00,560
methane can we land at some other

1345
00:56:05,590 --> 00:56:02,750
habitats and potential habitats and

1346
00:56:12,610 --> 00:56:05,600
scout them out for future life focused

1347
00:56:14,850 --> 00:56:12,620
missions I also agree that more

1348
00:56:17,440 --> 00:56:14,860
observations in diverse places are

1349
00:56:19,690 --> 00:56:17,450
interesting and important one of the

1350
00:56:21,850 --> 00:56:19,700
things for the small satellites that are

1351
00:56:25,180 --> 00:56:21,860
small missions to consider is actually

1352
00:56:30,250 --> 00:56:25,190
the operations so so running a mission

1353
00:56:32,980 --> 00:56:30,260
is like a whole nother ballgame and and

1354
00:56:34,690 --> 00:56:32,990
so one of the key things is not just to

1355
00:56:36,190 --> 00:56:34,700
think about what you send want to send

1356
00:56:37,840 --> 00:56:36,200
and what you want to measure but how are

1357
00:56:42,430 --> 00:56:37,850
you actually going to be able to use

1358
00:56:46,270 --> 00:56:42,440
that we need data downlink for example

1359
00:56:48,220 --> 00:56:46,280
we need an infrastructure for operations

1360
00:56:55,570 --> 00:56:48,230
and not just sending the small missions

1361
00:56:58,800 --> 00:56:55,580
I like the idea but it's awfully big I

1362
00:57:01,510 --> 00:56:58,810
think that the potential for using

1363
00:57:06,070 --> 00:57:01,520

multiple spacecraft assets on the ground

1364
00:57:08,440 --> 00:57:06,080
in in a way to network them together to

1365
00:57:11,740 --> 00:57:08,450
achieve a different type of science as

1366
00:57:14,050 --> 00:57:11,750
more of a regional basis maybe not

1367
00:57:16,840 --> 00:57:14,060
global in nature but regional is it's

1368
00:57:18,850 --> 00:57:16,850
possible in our future and I think

1369
00:57:20,980 --> 00:57:18,860
that's khana me it's going to be pretty

1370
00:57:22,600 --> 00:57:20,990
important to making that happen so I

1371
00:57:24,010 --> 00:57:22,610
think you're on the right path but I

1372
00:57:30,520 --> 00:57:24,020
would suggest you scale back a little

1373
00:57:32,980 --> 00:57:30,530
bit yeah I'll keep it quick so I I love

1374
00:57:35,170 --> 00:57:32,990
this idea actually personally it's a

1375
00:57:38,110 --> 00:57:35,180
future vision for Mars exploration that

1376
00:57:38,670 --> 00:57:38,120
I really like I think after Mars sample

1377
00:57:42,970 --> 00:57:38,680
return

1378
00:57:45,480 --> 00:57:42,980
I think we're likely to see a continued

1379
00:57:47,890 --> 00:57:45,490
focus on the push to get humans to Mars

1380
00:57:50,770 --> 00:57:47,900
that's likely to consume a lot of our

1381
00:57:51,380 --> 00:57:50,780
energy and resources but I would love to

1382
00:57:54,440 --> 00:57:51,390
see

1383
00:57:56,329 --> 00:57:54,450
program that that works on mapping Mars

1384
00:58:00,019 --> 00:57:56,339
at a much higher spatial resolution than

1385
00:58:01,220 --> 00:58:00,029
we currently have from orbit and there

1386
00:58:03,950 --> 00:58:01,230
are a lot of different concepts for

1387
00:58:05,299 --> 00:58:03,960
doing that but but it's a great I think

1388
00:58:08,750 --> 00:58:05,309

so yeah

1389
00:58:10,400 --> 00:58:08,760
next please our child's Cal Cal

1390
00:58:11,569 --> 00:58:10,410
University of Edinburgh I was wondering

1391
00:58:13,970 --> 00:58:11,579
whether the panel could say something

1392
00:58:15,049 --> 00:58:13,980
about the value of a lifeless Mars I

1393
00:58:17,089 --> 00:58:15,059
mean clearly it's difficult to show

1394
00:58:18,890 --> 00:58:17,099
there was no life on Mars but if we

1395
00:58:21,559 --> 00:58:18,900
looked in those paleo habitats that

1396
00:58:23,630 --> 00:58:21,569
Bethany showed and we didn't find any

1397
00:58:25,039 --> 00:58:23,640
evidence of life what would be the value

1398
00:58:26,870 --> 00:58:25,049
of those could they be useful for

1399
00:58:29,029 --> 00:58:26,880
control environments for example for

1400
00:58:31,250 --> 00:58:29,039
understanding geochemistry of early

1401
00:58:35,120 --> 00:58:31,260
Earth without life and also I think it

1402
00:58:37,549 --> 00:58:35,130
would be it would be deleterious to

1403
00:58:39,289 --> 00:58:37,559
convince the public that the lack the

1404
00:58:41,089 --> 00:58:39,299
lack of a discovery of life was somehow

1405
00:58:42,799 --> 00:58:41,099
some sort of disappointment for

1406
00:58:49,160 --> 00:58:42,809
astrobiology so my question for the

1407
00:58:50,450 --> 00:58:49,170
panel is Mars red and dead then what so

1408
00:58:52,279 --> 00:58:50,460
I think there's a lot of comments from

1409
00:58:53,990 --> 00:58:52,289
the panel that may come forward I think

1410
00:58:56,509 --> 00:58:54,000
there's an incredible amount of interest

1411
00:58:58,970 --> 00:58:56,519
in what kinds of prebiotic organic comp

1412
00:59:01,009 --> 00:58:58,980
organics may have been delivered or

1413
00:59:03,289 --> 00:59:01,019

preserved so gen started to speak about

1414
00:59:05,029 --> 00:59:03,299
this even in the systems that I was

1415
00:59:06,380 --> 00:59:05,039
discussing today where we're looking at

1416
00:59:08,690 --> 00:59:06,390
these mafic and ultramafic rocks

1417
00:59:10,819 --> 00:59:08,700
undergoing hydration there's a series

1418
00:59:12,620 --> 00:59:10,829
and cascade of carbon reduction

1419
00:59:13,910 --> 00:59:12,630
reactions that have been both

1420
00:59:15,230 --> 00:59:13,920
hypothesized and now we're getting

1421
00:59:16,940 --> 00:59:15,240
better at detecting them and rocks

1422
00:59:19,819 --> 00:59:16,950
recovered from the subsurface on earth

1423
00:59:21,380 --> 00:59:19,829
they are overprinted by biology if Mars

1424
00:59:24,589 --> 00:59:21,390
is lifeless and we can see the

1425
00:59:26,059 --> 00:59:24,599
distribution and the spatial arrangement

1426
00:59:27,529 --> 00:59:26,069
of how they're localized and the

1427
00:59:28,880 --> 00:59:27,539
processes that form them and that's

1428
00:59:32,960 --> 00:59:28,890
preserved that would be incredibly

1429
00:59:35,749 --> 00:59:32,970
useful information as well lack of

1430
00:59:37,940 --> 00:59:35,759
evidence of life in when for all these

1431
00:59:40,880 --> 00:59:37,950
missions would not be evidence for no

1432
00:59:43,099 --> 00:59:40,890
life on Mars it's a really hard one to

1433
00:59:46,549 --> 00:59:43,109
rule out however the best that we could

1434
00:59:48,440 --> 00:59:46,559
do is is go to places where we think

1435
00:59:50,779 --> 00:59:48,450
it's the best place for us to find it

1436
00:59:52,279 --> 00:59:50,789
that's tapping into everything we know

1437
00:59:54,410 --> 00:59:52,289
about astrobiology here on earth today

1438
00:59:56,630 --> 00:59:54,420

and how we relate it back to Mars and so

1439
00:59:58,519 --> 00:59:56,640
if we go when we look and we don't find

1440
01:00:01,220 --> 00:59:58,529
what we think should be there if there

1441
01:00:02,690 --> 01:00:01,230
is life then perhaps we just didn't go

1442
01:00:04,460 --> 01:00:02,700
to the right place perhaps life is

1443
01:00:05,150 --> 01:00:04,470
something different there than what we

1444
01:00:07,370 --> 01:00:05,160
expected and

1445
01:00:11,000 --> 01:00:07,380
Justin look we didn't use the right

1446
01:00:12,849 --> 01:00:11,010
tools to find it there's the internet

1447
01:00:17,240 --> 01:00:12,859
will still be unknowns

1448
01:00:19,549 --> 01:00:17,250
however because we're sending humans to

1449
01:00:21,319 --> 01:00:19,559
Mars there's also a potential that we're

1450
01:00:23,270 --> 01:00:21,329
going to be putting life there I know

1451
01:00:27,289 --> 01:00:23,280
that you know planetary protection aims

1452
01:00:29,900 --> 01:00:27,299
to keep it you know rather clean and

1453
01:00:32,180 --> 01:00:29,910
protect it but honestly if you put a

1454
01:00:34,880 --> 01:00:32,190
human on the surface their human is life

1455
01:00:36,859 --> 01:00:34,890
we would putting life on Mars no matter

1456
01:00:39,500 --> 01:00:36,869
what and so things might change on Mars

1457
01:00:42,589 --> 01:00:39,510
so one of the I think it's almost in in

1458
01:00:44,710 --> 01:00:42,599
the in generations of lifetimes here we

1459
01:00:47,539 --> 01:00:44,720
may be looking at the beginning of a

1460
01:00:52,640 --> 01:00:47,549
grand experiment I when we put humans on

1461
01:00:54,710 --> 01:00:52,650
Mars and what it means ration ology I'll

1462
01:00:56,630 --> 01:00:54,720
just say Charles that I love your idea

1463
01:00:57,650 --> 01:00:56,640

actually of uninhabited habitats and I

1464
01:00:59,329 --> 01:00:57,660
think it's a really important

1465
01:01:00,890 --> 01:00:59,339
consideration for astrobiology because

1466
01:01:03,349 --> 01:01:00,900
you know going back that the Drake

1467
01:01:06,349 --> 01:01:03,359
Equation you know is the classic right

1468
01:01:08,420 --> 01:01:06,359
like how many of but the key parameter

1469
01:01:10,099 --> 01:01:08,430
is right how many habitats if there are

1470
01:01:12,950 --> 01:01:10,109
habitats in the universe how what

1471
01:01:14,450 --> 01:01:12,960
fraction of them are inhabited I agree

1472
01:01:16,400 --> 01:01:14,460
it's hard to prove a negative for Mars

1473
01:01:17,870 --> 01:01:16,410
which is why I think the key question is

1474
01:01:19,760 --> 01:01:17,880
how do we explore it and how do we

1475
01:01:21,049 --> 01:01:19,770
explore it comprehensively taking into

1476
01:01:22,490 --> 01:01:21,059
account diversity taking into account

1477
01:01:24,620 --> 01:01:22,500
that we maybe want to look for modern

1478
01:01:27,230 --> 01:01:24,630
life before before sending humans or do

1479
01:01:28,880 --> 01:01:27,240
so in a in a intelligent way so these

1480
01:01:31,480 --> 01:01:28,890
are key questions that this community

1481
01:01:36,049 --> 01:01:31,490
will grapple with as we move forward

1482
01:01:39,859 --> 01:01:36,059
thank you so next please Mariupol versus

1483
01:01:44,120 --> 01:01:39,869
high school friends I have one Rima and

1484
01:01:48,579 --> 01:01:44,130
two questions for her dr. Alex C

1485
01:01:52,519 --> 01:01:48,589
Templeton taught the first remark is

1486
01:01:54,650 --> 01:01:52,529
that in the chemistry laboratory there

1487
01:01:57,680 --> 01:01:54,660
is a reaction which is well known and

1488
01:02:01,940 --> 01:01:57,690

which is never mentioned never presented

1489
01:02:07,990 --> 01:02:01,950
in astrobiology it is them the fact that

1490
01:02:12,829 --> 01:02:08,000
in a hco3 which is called sodium

1491
01:02:17,359 --> 01:02:12,839
bicarbonate decomposes at 50 degree

1492
01:02:18,210 --> 01:02:17,369
Celsius and entirely at 270 degree

1493
01:02:22,830 --> 01:02:18,220
Celsius

1494
01:02:26,460 --> 01:02:22,840
to farm CEO and I think it should be

1495
01:02:30,300 --> 01:02:26,470
considered in astrobiology in planetary

1496
01:02:35,100 --> 01:02:30,310
systems then I have two questions

1497
01:02:37,770 --> 01:02:35,110
you showed late at the start and I

1498
01:02:41,280 --> 01:02:37,780
misunderstood the name so I would like

1499
01:02:44,400 --> 01:02:41,290
to have the name and second I like to

1500
01:02:48,780 --> 01:02:44,410
know the length of the call that you

1501
01:02:50,760 --> 01:02:48,790
presented excellent so one thank you for

1502
01:02:53,640 --> 01:02:50,770
your comment about the bicarbonate

1503
01:02:55,560 --> 01:02:53,650
decomposition and carbon monoxide itself

1504
01:02:57,540 --> 01:02:55,570
is incredibly important right now for

1505
01:03:00,540 --> 01:02:57,550
understanding its formation and

1506
01:03:02,190 --> 01:03:00,550
reactivity even at low temperatures in

1507
01:03:03,990 --> 01:03:02,200
the pictures that I was showing in those

1508
01:03:04,350 --> 01:03:04,000
images what I was showing was in the

1509
01:03:05,820 --> 01:03:04,360
Oman

1510
01:03:08,250 --> 01:03:05,830
Afiya light where we have a massive

1511
01:03:09,510 --> 01:03:08,260
exposure of ultramafic rocks the moment

1512
01:03:11,490 --> 01:03:09,520
we have a series of areas that are

1513
01:03:13,110 --> 01:03:11,500

drilled approximately three to four

1514
01:03:15,570 --> 01:03:13,120
hundred meters it depends on the holes

1515
01:03:18,090 --> 01:03:15,580
with excellent core recovery so we have

1516
01:03:19,890 --> 01:03:18,100
100% core out of all the places that we

1517
01:03:21,390 --> 01:03:19,900
pulled those out from about a year ago

1518
01:03:23,400 --> 01:03:21,400
so those are the ones we're now doing

1519
01:03:27,750 --> 01:03:23,410
intensive life detection and an

1520
01:03:29,520 --> 01:03:27,760
assessment on and the water that you saw

1521
01:03:31,590 --> 01:03:29,530
emerging out of a subsurface environment

1522
01:03:33,210 --> 01:03:31,600
there's from the khofifah spring which

1523
01:03:35,460 --> 01:03:33,220
has been well studied geo chemically

1524
01:03:37,320 --> 01:03:35,470
Evert shocks lab and some of his

1525
01:03:39,450 --> 01:03:37,330
students here James Liang and Alta

1526
01:03:41,190 --> 01:03:39,460
Howells have been actually looking quite

1527
01:03:43,170 --> 01:03:41,200
a bit at the microbial communities there

1528
01:03:45,990 --> 01:03:43,180
in those discharge fluids coming to the

1529
01:03:47,400 --> 01:03:46,000
surface as well so that's the one of the

1530
01:03:49,530 --> 01:03:47,410
environments but these places where

1531
01:03:51,360 --> 01:03:49,540
bleed out of subsurface fluids occurs

1532
01:03:53,220 --> 01:03:51,370
it's been stored for very long periods

1533
01:04:00,030 --> 01:03:53,230
of time in the subsurface are quite

1534
01:04:01,440 --> 01:04:00,040
common thank you thank you so Nick Oh No

1535
01:04:03,840 --> 01:04:01,450
okay so next question please

1536
01:04:08,390 --> 01:04:03,850
the actual Samarco from the Technical

1537
01:04:10,940 --> 01:04:08,400
University Berlin so my questions

1538
01:04:15,180 --> 01:04:10,950

probably go a little bit further back

1539
01:04:17,340 --> 01:04:15,190
retains to earth Mars sample return so

1540
01:04:19,710 --> 01:04:17,350
from the Viking mission if if one thing

1541
01:04:22,110 --> 01:04:19,720
learned there is if you put something in

1542
01:04:24,240 --> 01:04:22,120
the Box you know so whatever you measure

1543
01:04:28,110 --> 01:04:24,250
that the chemical reactivity or the bio

1544
01:04:30,480 --> 01:04:28,120
biology was gone after a while so my

1545
01:04:31,170 --> 01:04:30,490
question is the following so when your

1546
01:04:35,490 --> 01:04:31,180
goat

1547
01:04:37,950 --> 01:04:35,500
when you visit Mass 2020 if you sample

1548
01:04:40,530 --> 01:04:37,960
something in the keshe what is the

1549
01:04:43,200 --> 01:04:40,540
selection mechanism what kind how do you

1550
01:04:45,780 --> 01:04:43,210
decide what sample you take and is there

1551
01:04:47,910 --> 01:04:45,790
anything that you measure before you put

1552
01:04:49,890 --> 01:04:47,920
it in the box what is what it is

1553
01:04:51,930 --> 01:04:49,900
actually what you put in the box is

1554
01:04:55,980 --> 01:04:51,940
there any kind of in situ measurement

1555
01:04:58,050 --> 01:04:55,990
and if not why not I think we should let

1556
01:04:59,550 --> 01:04:58,060
can answer that with his project science

1557
01:05:05,190 --> 01:04:59,560
has had on aldo i'll be happy to chime

1558
01:05:08,430 --> 01:05:05,200
in sure ok so first of all i want to

1559
01:05:12,020 --> 01:05:08,440
mention that that mars 2020 objectives

1560
01:05:14,370 --> 01:05:12,030
and the objectives of Mars sample return

1561
01:05:15,960 --> 01:05:14,380
to the extent that they currently exist

1562
01:05:18,060 --> 01:05:15,970
you know the currently the current

1563
01:05:22,110 --> 01:05:18,070

vision from our sample return is focused

1564
01:05:24,000 --> 01:05:22,120
on ancient life and so it's certainly

1565
01:05:25,650 --> 01:05:24,010
true that if we're successful in

1566
01:05:27,480 --> 01:05:25,660
bringing samples back people will be

1567
01:05:30,150 --> 01:05:27,490
interested in looking for evidence of

1568
01:05:33,180 --> 01:05:30,160
extant life in those samples but our

1569
01:05:34,770 --> 01:05:33,190
focus is on understanding whether or not

1570
01:05:36,770 --> 01:05:34,780
there's evidence for ancient life on

1571
01:05:39,030 --> 01:05:36,780
Mars so there's very different concerns

1572
01:05:41,370 --> 01:05:39,040
in terms of what you alluded to with

1573
01:05:43,080 --> 01:05:41,380
putting things in a box and signs are

1574
01:05:46,110 --> 01:05:43,090
there and then they're not there now you

1575
01:05:48,900 --> 01:05:46,120
specifically ask how do we choose the

1576
01:05:50,730 --> 01:05:48,910
samples that's I don't know near enough

1577
01:05:52,980 --> 01:05:50,740
time to talk about that but that's that

1578
01:05:55,140 --> 01:05:52,990
is what I kind of spend 100% of my time

1579
01:05:57,330 --> 01:05:55,150
thinking about with the science team is

1580
01:05:59,040 --> 01:05:57,340
we're developing that plan right now and

1581
01:06:01,890 --> 01:05:59,050
we have been for years and it's ramping

1582
01:06:04,290 --> 01:06:01,900
up we're focusing on our strategic

1583
01:06:06,330 --> 01:06:04,300
planning right now for you know I showed

1584
01:06:08,700 --> 01:06:06,340
you where we're planning to go so we

1585
01:06:10,380 --> 01:06:08,710
have that level of plan but it gets much

1586
01:06:12,570 --> 01:06:10,390
more detailed than that so we're mapping

1587
01:06:15,000 --> 01:06:12,580
the landing site now and select regions

1588
01:06:17,520 --> 01:06:15,010

of interest will will choose campaigns

1589
01:06:19,350 --> 01:06:17,530
within those regions of interest and

1590
01:06:21,810 --> 01:06:19,360
we'll explore that territory using a

1591
01:06:24,030 --> 01:06:21,820
model that looks similar to MSL but

1592
01:06:25,770 --> 01:06:24,040
where the exploration is really focused

1593
01:06:28,470 --> 01:06:25,780
on guiding us toward the selection of

1594
01:06:30,270 --> 01:06:28,480
those samples we will be making many

1595
01:06:32,820 --> 01:06:30,280
in-situ measurements before we put

1596
01:06:34,890 --> 01:06:32,830
before we choose a sample they sir

1597
01:06:37,470 --> 01:06:34,900
culminate in these mapping instruments

1598
01:06:39,480 --> 01:06:37,480
where we deploy the arm and we'll abrade

1599
01:06:41,430 --> 01:06:39,490
a target we have an abrading bit of the

1600
01:06:43,950 --> 01:06:41,440
drill so we'll braid about a four and a

1601
01:06:44,590 --> 01:06:43,960
half centimeter circle and flatten that

1602
01:06:47,110 --> 01:06:44,600
that

1603
01:06:50,530 --> 01:06:47,120
Rock surface and then we'll deploy pixel

1604
01:06:52,330 --> 01:06:50,540
instrument to make a Elemental map over

1605
01:06:54,430 --> 01:06:52,340
a couple square centimeters with a beam

1606
01:06:56,110 --> 01:06:54,440
size of a hundred microns and we'll make

1607
01:06:58,480 --> 01:06:56,120
a couette spatially Co registered

1608
01:07:02,140 --> 01:06:58,490
Sherlock map where we're mapping with a

1609
01:07:04,210 --> 01:07:02,150
Raman spectrometer to potentially detect

1610
01:07:06,370 --> 01:07:04,220
organic matter but also get mineralogy

1611
01:07:09,070 --> 01:07:06,380
at that same scale and that will of

1612
01:07:11,560 --> 01:07:09,080
course be taken together with visible

1613
01:07:13,840 --> 01:07:11,570

light images with the watson imager and

1614
01:07:15,550 --> 01:07:13,850
so that's our sort of richest data set

1615
01:07:17,440 --> 01:07:15,560
all that obviously is supported by the

1616
01:07:19,990 --> 01:07:17,450
remote science instruments but that's

1617
01:07:21,970 --> 01:07:20,000
our richest data set to tell us what

1618
01:07:24,430 --> 01:07:21,980
we're what we likely have sampled we

1619
01:07:26,170 --> 01:07:24,440
probably will not sample exactly what we

1620
01:07:28,570 --> 01:07:26,180
mapped but something as close as

1621
01:07:31,120 --> 01:07:28,580
possible to that where we have you know

1622
01:07:32,530 --> 01:07:31,130
good reason to believe that our sample

1623
01:07:34,060 --> 01:07:32,540
that the data we've taken are

1624
01:07:36,160 --> 01:07:34,070
representative of the sample that's in

1625
01:07:38,710 --> 01:07:36,170
the tube what we will not be doing is

1626
01:07:41,260 --> 01:07:38,720
making any measurement on the sample

1627
01:07:43,690 --> 01:07:41,270
itself that we've collected after we've

1628
01:07:46,000 --> 01:07:43,700
sampled it so once we decide drill here

1629
01:07:47,920 --> 01:07:46,010
the next thing we know is we have data

1630
01:07:50,140 --> 01:07:47,930
down that says you drilled it it's in

1631
01:07:52,870 --> 01:07:50,150
the tube it's sealed up we should have

1632
01:07:55,480 --> 01:07:52,880
one picture of the top of that sample

1633
01:07:57,700 --> 01:07:55,490
from taken from inside the rover but

1634
01:08:02,890 --> 01:07:57,710
that's it until the sample comes back to

1635
01:08:05,470 --> 01:08:02,900
earth so we we have about five minutes

1636
01:08:08,200 --> 01:08:05,480
left so we the finalists have to also

1637
01:08:11,260 --> 01:08:08,210
try to be brief we have five people

1638
01:08:13,660 --> 01:08:11,270

let's see how far out can we get yeah

1639
01:08:16,510 --> 01:08:13,670
please go ahead uh I'd like to start

1640
01:08:18,310 --> 01:08:16,520
with Barbara sure Laura and end with Don

1641
01:08:20,620 --> 01:08:18,320
Sumner and the other panelists in

1642
01:08:22,930 --> 01:08:20,630
situations of some between and answering

1643
01:08:24,610 --> 01:08:22,940
this question and maybe each of the

1644
01:08:27,120 --> 01:08:24,620
panelists could say how to sample the

1645
01:08:32,080 --> 01:08:27,130
atmosphere according to according to

1646
01:08:36,790 --> 01:08:32,090
include that in their answer uh if there

1647
01:08:41,010 --> 01:08:36,800
was some carbonate shown on the the Mars

1648
01:08:44,140 --> 01:08:41,020
2020 sample shot and assuming that

1649
01:08:46,330 --> 01:08:44,150
there's been some sub alteration by

1650
01:08:49,360 --> 01:08:46,340
impacts and maybe some of the rocks have

1651
01:08:51,310 --> 01:08:49,370
been the mineralogy has changed so that

1652
01:08:52,810 --> 01:08:51,320
you could generate low molecular weight

1653
01:08:55,239 --> 01:08:52,820
organic compounds

1654
01:09:01,239 --> 01:08:55,249
how would you

1655
01:09:03,099 --> 01:09:01,249
in order to look for signs of life or

1656
01:09:05,469 --> 01:09:03,109
life that might have organised itself

1657
01:09:08,349 --> 01:09:05,479
saying stromatolite layers on a very

1658
01:09:11,879 --> 01:09:08,359
small scale how would you sample and get

1659
01:09:15,039 --> 01:09:11,889
that chemical gradient and in order that

1660
01:09:17,410 --> 01:09:15,049
solutes moving cells excreting

1661
01:09:26,859 --> 01:09:17,420
substances from the small to the large

1662
01:09:30,459 --> 01:09:26,869
scale across the given sample I'll try

1663
01:09:32,169 --> 01:09:30,469

to snap off one side of it in in my own

1664
01:09:35,589 --> 01:09:32,179
context is an isotope geochemistry and

1665
01:09:36,609 --> 01:09:35,599
and gas geochemists around the methane

1666
01:09:38,289 --> 01:09:36,619
question one of the things that I

1667
01:09:40,120 --> 01:09:38,299
emphasize is that the contextual

1668
01:09:41,919 --> 01:09:40,130
evidence from the other associated gases

1669
01:09:43,719 --> 01:09:41,929
can be critical so if we're trying to

1670
01:09:46,269 --> 01:09:43,729
really understand even on this planet

1671
01:09:48,729 --> 01:09:46,279
the distribution of abiotic methane

1672
01:09:50,410 --> 01:09:48,739
versus biological methane two of the

1673
01:09:52,779 --> 01:09:50,420
really critical aspects to measure are

1674
01:09:55,270 --> 01:09:52,789
actually much as I love carbon isotope

1675
01:09:56,979 --> 01:09:55,280
signatures what I measure first is the

1676
01:09:59,350 --> 01:09:56,989
hydrogen and the ethane because the

1677
01:10:01,750 --> 01:09:59,360
ratios between those three can be quite

1678
01:10:03,160 --> 01:10:01,760
illustrative of the origin of the

1679
01:10:05,500 --> 01:10:03,170
methane I'll talk more about that at

1680
01:10:07,120 --> 01:10:05,510
1:45 this afternoon but I'm gonna pass

1681
01:10:12,640 --> 01:10:07,130
that on because your question was much

1682
01:10:14,709 --> 01:10:12,650
more wide-ranging and so it just gets

1683
01:10:17,109 --> 01:10:14,719
back at the last question to a sample

1684
01:10:20,680 --> 01:10:17,119
selection and and one of the things we

1685
01:10:22,689 --> 01:10:20,690
do is we we use we start with images to

1686
01:10:25,419 --> 01:10:22,699
see what we're looking at we look for

1687
01:10:28,060 --> 01:10:25,429
things in particular that don't look

1688
01:10:30,759 --> 01:10:28,070

like they might be physical or abiotic

1689
01:10:32,770 --> 01:10:30,769
chemical processes and and there's a lot

1690
01:10:35,439 --> 01:10:32,780
of ambiguity in the morphological

1691
01:10:38,830 --> 01:10:35,449
signatures but we start with just

1692
01:10:41,859 --> 01:10:38,840
standing back and then closer and closer

1693
01:10:43,479 --> 01:10:41,869
imaging and in both pixel and Sherlock

1694
01:10:46,000 --> 01:10:43,489
are going to be really critical to

1695
01:10:50,680 --> 01:10:46,010
giving us clues to to the chemistry and

1696
01:10:53,290 --> 01:10:50,690
so we sort of take all the knowledge we

1697
01:10:55,390 --> 01:10:53,300
have of life on Earth and physical and

1698
01:10:57,939 --> 01:10:55,400
chemical processes and try to expand

1699
01:10:59,620 --> 01:10:57,949
that beyond the specific metabolisms to

1700
01:11:02,649 --> 01:10:59,630
choose something that when we get it

1701
01:11:04,870 --> 01:11:02,659
back and put it in someone's lab where

1702
01:11:06,759 --> 01:11:04,880
they have people who can separate out

1703
01:11:09,010 --> 01:11:06,769
the components and not just burn the

1704
01:11:12,130 --> 01:11:09,020
organic carbon with the perchlorates

1705
01:11:12,940 --> 01:11:12,140
um we can actually sort out a lot more

1706
01:11:15,220 --> 01:11:12,950
what it is

1707
01:11:17,110 --> 01:11:15,230
so we basically use all scales of

1708
01:11:19,480 --> 01:11:17,120
observations and everyone's field

1709
01:11:22,240 --> 01:11:19,490
techniques to try to get the best sample

1710
01:11:25,870 --> 01:11:22,250
for analysis hopefully back into the

1711
01:11:27,550 --> 01:11:25,880
best labs in the world I feared this

1712
01:11:30,750 --> 01:11:27,560
might be the last question and I haven't

1713
01:11:33,820 --> 01:11:30,760

taken any from the left so far left hi

1714
01:11:36,610 --> 01:11:33,830
Katherine Maggiore McGill University I

1715
01:11:38,920 --> 01:11:36,620
believe that you said can that the focus

1716
01:11:40,300 --> 01:11:38,930
right now although is on sample caching

1717
01:11:43,240 --> 01:11:40,310
and sample returned that that might

1718
01:11:47,110 --> 01:11:43,250
shift to human exploration after Mars

1719
01:11:49,780 --> 01:11:47,120
2020 of course humans are walking

1720
01:11:52,840 --> 01:11:49,790
microbial incubators so once that begins

1721
01:11:55,600 --> 01:11:52,850
we will revoke ibly contaminate Mars

1722
01:11:58,200 --> 01:11:55,610
with us so will there be any kind of

1723
01:12:00,760 --> 01:11:58,210
shift from searching for extant life and

1724
01:12:01,390 --> 01:12:00,770
habitability to may be searching for or

1725
01:12:08,110 --> 01:12:01,400
searching

1726
01:12:10,030 --> 01:12:08,120
extinct life well the question you know

1727
01:12:13,110 --> 01:12:10,040
the real answer to that question is

1728
01:12:15,130 --> 01:12:13,120
number one uncertain and number two

1729
01:12:17,680 --> 01:12:15,140
absolutely above my paygrade

1730
01:12:20,230 --> 01:12:17,690
so what I said when I said you know I

1731
01:12:22,600 --> 01:12:20,240
think our you know we will continue to

1732
01:12:25,450 --> 01:12:22,610
focus on humans to Mars that's me

1733
01:12:27,070 --> 01:12:25,460
thinking that I have my own opinions

1734
01:12:31,720 --> 01:12:27,080
about it but but I think what you

1735
01:12:33,490 --> 01:12:31,730
mentioned is a is a definitely worth

1736
01:12:37,180 --> 01:12:33,500
considering and probably a very good

1737
01:12:39,880 --> 01:12:37,190
idea to so we've taken this path toward

1738
01:12:42,670 --> 01:12:39,890

follow the water you know look like

1739
01:12:44,080 --> 01:12:42,680
follow the water to follow the

1740
01:12:45,610 --> 01:12:44,090
habitability you know look at it

1741
01:12:49,660 --> 01:12:45,620
happened to building a more nuanced way

1742
01:12:52,450 --> 01:12:49,670
Mars 2020 now has a much more clear

1743
01:12:53,950 --> 01:12:52,460
focus on directly looking for evidence

1744
01:12:56,350 --> 01:12:53,960
of ancient life than the previous

1745
01:12:57,910 --> 01:12:56,360
missions have going back to the Viking

1746
01:12:59,350 --> 01:12:57,920
really where Viking was looking at

1747
01:13:01,840 --> 01:12:59,360
extant life but as you said we're

1748
01:13:04,480 --> 01:13:01,850
looking at ancient life yeah do we want

1749
01:13:07,090 --> 01:13:04,490
to as a community and does NASA want to

1750
01:13:09,670 --> 01:13:07,100
as an agency commit to to really

1751
01:13:11,680 --> 01:13:09,680
seriously attacking the question of

1752
01:13:13,570 --> 01:13:11,690
excellent life on Mars before human

1753
01:13:14,200 --> 01:13:13,580
exploration it's a critical question to

1754
01:13:17,170 --> 01:13:14,210
consider

1755
01:13:19,150 --> 01:13:17,180
I personally believe we can do both and

1756
01:13:20,770 --> 01:13:19,160
I think we can you know we often say

1757
01:13:23,200 --> 01:13:20,780
Mars is a rabbit

1758
01:13:25,360 --> 01:13:23,210
relatively contaminated and all you know

1759
01:13:27,460 --> 01:13:25,370
all astrobiology is over once humans get

1760
01:13:29,620 --> 01:13:27,470
there that's not how I think of it I

1761
01:13:32,170 --> 01:13:29,630
think we can do it intelligently and we

1762
01:13:38,590 --> 01:13:32,180
can do both and the humans can be

1763
01:13:39,300 --> 01:13:38,600

enabling thank you okay yeah go okay

1764
01:13:42,430 --> 01:13:39,310
I'll keep it short

1765
01:13:45,010 --> 01:13:42,440
um I'm really glad that you asked this

1766
01:13:47,950 --> 01:13:45,020
question because this community right

1767
01:13:50,980 --> 01:13:47,960
here you this is the community that can

1768
01:13:53,290 --> 01:13:50,990
enable the science of making an extant

1769
01:13:55,540 --> 01:13:53,300
life search happen now several years ago

1770
01:13:57,310 --> 01:13:55,550
some of us you know kind of evaluate

1771
01:14:00,640 --> 01:13:57,320
well why would we put a priority on

1772
01:14:02,560 --> 01:14:00,650
ancient life over extant life and what

1773
01:14:04,420 --> 01:14:02,570
it claimed boiled down to was we weren't

1774
01:14:06,400 --> 01:14:04,430
sure how to do it yeah we weren't sure

1775
01:14:08,230 --> 01:14:06,410
how to do a search for expand life and

1776
01:14:10,150 --> 01:14:08,240
it has a lot of different challenges to

1777
01:14:12,100 --> 01:14:10,160
it including the technology the

1778
01:14:14,260 --> 01:14:12,110
contamination control and then what

1779
01:14:16,030 --> 01:14:14,270
biosignatures do you look for not

1780
01:14:18,790 --> 01:14:16,040
knowing what the life is going to be and

1781
01:14:20,920 --> 01:14:18,800
so I I think that we are at that

1782
01:14:22,780 --> 01:14:20,930
forefront we're ready to do that expand

1783
01:14:26,260 --> 01:14:22,790
search hopefully prior to presenting

1784
01:14:28,150 --> 01:14:26,270
humans but the how and we do it is

1785
01:14:30,000 --> 01:14:28,160
something that can still take shape and

1786
01:14:33,040 --> 01:14:30,010
this community can contribute to that