Dr. Kathryn Stack-Morgan: One Year in Jezero Crater with Perseverance & Dr. Meenakshi Wadhwa: the Astrobiological Potential of Mars

1
00:00:01,280 --> 00:00:05,349
good morning everyone

2
00:00:11,910 --> 00:00:08,150
so great to see you all

3
00:00:14,470 --> 00:00:11,920
welcome to ebbs icon tuesday

4
00:00:17,590 --> 00:00:14,480
uh and welcome welcome to atlanta i'm

5
00:00:19,429 --> 00:00:17,600
martha grover i'm from georgia tech so

6
00:00:21,830 --> 00:00:19,439
we're very happy

7
00:00:24,070 --> 00:00:21,840
happy to have you here in atlanta and

8
00:00:27,910 --> 00:00:24,080
also those of you who are online

9
00:00:31,990 --> 00:00:29,750
i'd like to to start out with a couple

10
00:00:33,590 --> 00:00:32,000
of announcements um first of all i'd

11
00:00:34,870 --> 00:00:33,600
like to encourage you all to check out

12
00:00:36,389 --> 00:00:34,880
brain dates

13
00:00:38,630 --> 00:00:36,399

if you haven't already done that has

14
00:00:40,470 --> 00:00:38,640
anyone checked out brain dates already

15
00:00:42,310 --> 00:00:40,480
yes good so we have a lot of great

16
00:00:43,670 --> 00:00:42,320
topics already so you can join one of

17
00:00:45,670 --> 00:00:43,680
those discussions

18
00:00:48,150 --> 00:00:45,680
but please don't be shy about

19
00:00:50,069 --> 00:00:48,160
suggesting another discussion topic so

20
00:00:51,350 --> 00:00:50,079
just encourage you to go ahead and check

21
00:00:53,510 --> 00:00:51,360
out brain dates

22
00:00:55,590 --> 00:00:53,520
i'd also like to announce

23
00:00:58,389 --> 00:00:55,600
and introduce you to the astrobiology

24
00:01:00,630 --> 00:00:58,399
diversity and inclusion survey which is

25
00:01:02,709 --> 00:01:00,640
led by arsav adinolu

26
00:01:05,270 --> 00:01:02,719
who's an assistant professor at middle

27
00:01:07,990 --> 00:01:05,280
east technical university so the survey

28
00:01:10,710 --> 00:01:08,000
aims to identify whether gender and race

29
00:01:13,030 --> 00:01:10,720
impact research careers and is open to

30
00:01:14,149 --> 00:01:13,040
anyone who is interested in astrobiology

31
00:01:15,749 --> 00:01:14,159
so

32
00:01:18,070 --> 00:01:15,759
all of you since you're here at the

33
00:01:21,350 --> 00:01:18,080
conference it takes about 20 minutes to

34
00:01:23,030 --> 00:01:21,360
complete and is available now through

35
00:01:24,710 --> 00:01:23,040
june 16th but i encourage you to go

36
00:01:27,109 --> 00:01:24,720
ahead and fill it out while you're here

37
00:01:28,870 --> 00:01:27,119
and it's on your mind it's available on

38
00:01:31,429 --> 00:01:28,880

surveymonkey and you'll be getting the

39
00:01:33,670 --> 00:01:31,439
link for that from the conference

40
00:01:36,630 --> 00:01:33,680
so thank you for that ourselves

41
00:01:38,870 --> 00:01:36,640
um and then uh with that i'd like to go

42
00:01:42,069 --> 00:01:38,880
ahead and get started with our tuesday

43
00:01:44,870 --> 00:01:42,079
plenary so we have a two speakers here

44
00:01:46,550 --> 00:01:44,880
today uh both on the topic of mars

45
00:01:48,469 --> 00:01:46,560
exploration

46
00:01:51,270 --> 00:01:48,479
and so after the first speaker we'll

47
00:01:53,429 --> 00:01:51,280
have a few minutes for questions but

48
00:01:54,550 --> 00:01:53,439
then after the second speaker will have

49
00:01:57,109 --> 00:01:54,560
a longer

50
00:01:58,630 --> 00:01:57,119
question and discussion period with both

51
00:02:01,030 --> 00:01:58,640
speakers together

52
00:02:03,270 --> 00:02:01,040
and so so we can continue the discussion

53
00:02:04,950 --> 00:02:03,280
discussion then so after the first

54
00:02:07,350 --> 00:02:04,960
speaker finishes if you have a question

55
00:02:10,150 --> 00:02:07,360
come on up to the microphone quickly so

56
00:02:11,270 --> 00:02:10,160
we can have a few specific questions but

57
00:02:13,350 --> 00:02:11,280
also keep

58
00:02:15,750 --> 00:02:13,360
keep to our schedule

59
00:02:17,910 --> 00:02:15,760
so our first plenary speaker this

60
00:02:20,150 --> 00:02:17,920
morning is dr catherine

61
00:02:22,790 --> 00:02:20,160
stack morgan

62
00:02:24,869 --> 00:02:22,800
katie is a research scientist at the jet

63
00:02:27,990 --> 00:02:24,879

propulsion laboratory

64
00:02:31,190 --> 00:02:28,000
the deputy project scientist of the mars

65
00:02:33,830 --> 00:02:31,200
2020 perseverance rover and a

66
00:02:36,630 --> 00:02:33,840
participating scientist on the mars

67
00:02:38,630 --> 00:02:36,640
science laboratory curiosity rover

68
00:02:41,190 --> 00:02:38,640
mission

69
00:02:43,910 --> 00:02:41,200
she graduated with a ba in geology and

70
00:02:46,790 --> 00:02:43,920
astronomy from williams college and

71
00:02:48,710 --> 00:02:46,800
earned her master's and phd in geology

72
00:02:51,430 --> 00:02:48,720
from caltech

73
00:02:53,830 --> 00:02:51,440
for her work on the curiosity rover she

74
00:02:57,350 --> 00:02:53,840
was named to the 2013

75
00:02:59,910 --> 00:02:57,360
forbes list of 30 under 30 and has

76
00:03:00,949 --> 00:02:59,920
earned several nasa group achievement

77
00:03:04,630 --> 00:03:00,959
awards

78
00:03:07,270 --> 00:03:04,640
and a nasa software of the year award

79
00:03:10,309 --> 00:03:07,280
katie's research focuses on the martian

80
00:03:13,190 --> 00:03:10,319
sedimentary rock record using orbiter

81
00:03:16,309 --> 00:03:13,200
and rover image data to understand the

82
00:03:19,110 --> 00:03:16,319
evolution of ancient surface processes

83
00:03:26,470 --> 00:03:19,120
on mars please join me in giving a warm

84
00:03:30,309 --> 00:03:28,149
all right thank you so much martha for

85
00:03:32,710 --> 00:03:30,319
that great introduction

86
00:03:39,589 --> 00:03:32,720
let me see if i can go ahead and share

87
00:03:39,599 --> 00:03:43,509
okay there we go

88
00:03:47,350 --> 00:03:45,350

all right well thank you so much for

89
00:03:49,509 --> 00:03:47,360
joining me today and i'm sorry i

90
00:03:51,190 --> 00:03:49,519
couldn't be there in person uh but i

91
00:03:53,670 --> 00:03:51,200
very much appreciate the opportunity to

92
00:03:55,670 --> 00:03:53,680
participate uh remotely as i'm currently

93
00:03:57,910 --> 00:03:55,680
laid off recovering from achilles uh

94
00:04:00,789 --> 00:03:57,920
rupture surgery um but today i'm very

95
00:04:03,750 --> 00:04:00,799
excited to share with you um the results

96
00:04:05,429 --> 00:04:03,760
from the past year uh of the mars 2020

97
00:04:06,390 --> 00:04:05,439
perseverance rover mission in jezreel

98
00:04:08,149 --> 00:04:06,400
crater

99
00:04:10,070 --> 00:04:08,159
from the perspective of the habitable

100
00:04:12,710 --> 00:04:10,080
environments that we have thus far been

101
00:04:14,710 --> 00:04:12,720
able to explore with the rover

102
00:04:16,870 --> 00:04:14,720
i did want to give a shout out to mars

103
00:04:18,870 --> 00:04:16,880
2020 at abs icon

104
00:04:20,789 --> 00:04:18,880
i think you heard yesterday from uh one

105
00:04:23,350 --> 00:04:20,799
of our scientists ananda sharma talking

106
00:04:25,270 --> 00:04:23,360
about bio signatures in jezreel this

107
00:04:27,430 --> 00:04:25,280
coming thursday we have a number of

108
00:04:30,150 --> 00:04:27,440
great talks where you can find out more

109
00:04:31,830 --> 00:04:30,160
details about mars 2020 and the great

110
00:04:34,550 --> 00:04:31,840
science and astrobiology that we are

111
00:04:36,230 --> 00:04:34,560
doing um and as well as on the online

112
00:04:38,230 --> 00:04:36,240
sessions as well so i'll give an

113
00:04:40,150 --> 00:04:38,240

overview here but um very much uh

114
00:04:42,390 --> 00:04:40,160
encourage you all to go to these talks

115
00:04:43,590 --> 00:04:42,400
uh to get more details on what mars 2020

116
00:04:45,830 --> 00:04:43,600
is up to

117
00:04:48,390 --> 00:04:45,840
all right so the mars 2020 perseverance

118
00:04:50,550 --> 00:04:48,400
rover um is here in terms of the fleet

119
00:04:51,590 --> 00:04:50,560
of of nasa and mars missions past and

120
00:04:54,310 --> 00:04:51,600
future

121
00:04:57,350 --> 00:04:54,320
uh building on the fantastic heritage of

122
00:04:59,430 --> 00:04:57,360
missions like the spirit and opportunity

123
00:05:01,590 --> 00:04:59,440
mars exploration rovers as well as

124
00:05:03,830 --> 00:05:01,600
particularly curiosity rover that's

125
00:05:06,469 --> 00:05:03,840
still currently operating on mars and

126
00:05:08,710 --> 00:05:06,479
mars 2020 uh perseverance rover feeds

127
00:05:10,629 --> 00:05:08,720
into and is the start of a mars sample

128
00:05:12,870 --> 00:05:10,639
return campaign we'll hear more about

129
00:05:13,670 --> 00:05:12,880
that from mini later this morning

130
00:05:16,150 --> 00:05:13,680
and

131
00:05:18,870 --> 00:05:16,160
we are the first leg of that campaign

132
00:05:20,550 --> 00:05:18,880
whose job is to collect and cash uh

133
00:05:23,189 --> 00:05:20,560
samples on the surface of mars for

134
00:05:25,430 --> 00:05:23,199
potential return to earth by the mars

135
00:05:28,629 --> 00:05:25,440
sample return missions

136
00:05:30,710 --> 00:05:28,639
okay so the mars 2020 rover has uh four

137
00:05:32,870 --> 00:05:30,720
main objectives i'll actually start with

138
00:05:35,110 --> 00:05:32,880

the first and last and then dig into a

139
00:05:35,990 --> 00:05:35,120
bit more detail on the the second and

140
00:05:38,710 --> 00:05:36,000
third

141
00:05:40,629 --> 00:05:38,720
like other missions mars 2020 is focused

142
00:05:43,189 --> 00:05:40,639
on understanding the geology of the

143
00:05:44,629 --> 00:05:43,199
landing site that the rover is exploring

144
00:05:47,189 --> 00:05:44,639
understanding what's present what its

145
00:05:49,110 --> 00:05:47,199
geologic history is and like many

146
00:05:50,870 --> 00:05:49,120
missions before it

147
00:05:53,270 --> 00:05:50,880
this mission takes small steps in

148
00:05:54,629 --> 00:05:53,280
preparing for human exploration with the

149
00:05:56,390 --> 00:05:54,639
inclusion of certain technology

150
00:05:58,870 --> 00:05:56,400
demonstrations and exciting engineering

151
00:06:01,029 --> 00:05:58,880
capabilities to help get humans to mars

152
00:06:02,390 --> 00:06:01,039
in the future um

153
00:06:04,150 --> 00:06:02,400
specifically though the the two

154
00:06:07,189 --> 00:06:04,160
objectives that really distinguish this

155
00:06:09,749 --> 00:06:07,199
mission are b and c astrobiology and

156
00:06:13,029 --> 00:06:09,759
sample caching and so in terms of

157
00:06:15,110 --> 00:06:13,039
astrobiology mars 2020 is seeking signs

158
00:06:17,430 --> 00:06:15,120
of ancient life and and so what does

159
00:06:19,110 --> 00:06:17,440
that mean for us so mars you know

160
00:06:21,189 --> 00:06:19,120
previous missions have also looked for

161
00:06:24,070 --> 00:06:21,199
signs of life on on mars but i think the

162
00:06:26,550 --> 00:06:24,080
mars 2020 rover has a payload that is

163
00:06:28,469 --> 00:06:26,560

uniquely suited and probably best suited

164
00:06:30,870 --> 00:06:28,479
for finding signs of ancient life on

165
00:06:33,430 --> 00:06:30,880
mars and so in our search for bio

166
00:06:36,309 --> 00:06:33,440
signatures on mars um

167
00:06:38,710 --> 00:06:36,319
we set certain expectations if life

168
00:06:41,029 --> 00:06:38,720
emerged on mars it was likely microbial

169
00:06:42,710 --> 00:06:41,039
life so we're talking microscopic and

170
00:06:44,629 --> 00:06:42,720
with the possibility that any soft

171
00:06:46,950 --> 00:06:44,639
organic matter that might have made up

172
00:06:49,350 --> 00:06:46,960
this life was probably easily degraded

173
00:06:51,510 --> 00:06:49,360
and not particularly well preserved in

174
00:06:53,189 --> 00:06:51,520
the rock record fortunately though we

175
00:06:55,270 --> 00:06:53,199
know based on our studies of microbes

176
00:06:57,350 --> 00:06:55,280
here on earth that microbes can interact

177
00:06:59,830 --> 00:06:57,360
with their environment to trap sediment

178
00:07:02,150 --> 00:06:59,840
and precipitate amorphous materials or

179
00:07:03,990 --> 00:07:02,160
minerals that we then can see preserved

180
00:07:07,110 --> 00:07:04,000
in the rock record with the potential to

181
00:07:09,029 --> 00:07:07,120
leave behind biosignatures and so these

182
00:07:10,469 --> 00:07:09,039
interactions result in a wide range of

183
00:07:12,230 --> 00:07:10,479
things that we could potentially search

184
00:07:14,469 --> 00:07:12,240
for both in the early rock record of

185
00:07:16,469 --> 00:07:14,479
earth but on mars as well

186
00:07:18,230 --> 00:07:16,479
in particular the mars 2020 perseverance

187
00:07:20,390 --> 00:07:18,240
rover with examples over here on the

188
00:07:22,150 --> 00:07:20,400

right um by pixel and sherlock are

189
00:07:24,710 --> 00:07:22,160
particularly well suited for searching

190
00:07:27,350 --> 00:07:24,720
for things like biomarkers morphological

191
00:07:29,110 --> 00:07:27,360
biosignatures as well as some elemental

192
00:07:30,629 --> 00:07:29,120
patterns and so you can see here an

193
00:07:33,430 --> 00:07:30,639
example of that with our pixel and

194
00:07:35,510 --> 00:07:33,440
sherlock instruments by the combining

195
00:07:37,990 --> 00:07:35,520
mapping of elemental geochemistry with

196
00:07:40,230 --> 00:07:38,000
organics and mineralogy coupled with

197
00:07:41,909 --> 00:07:40,240
high resolution images of texture we

198
00:07:44,309 --> 00:07:41,919
have the ability to potentially put

199
00:07:46,309 --> 00:07:44,319
together a case for a biosignature on

200
00:07:47,990 --> 00:07:46,319
the surface of mars

201
00:07:50,629 --> 00:07:48,000
and so this particular objective that

202
00:07:53,510 --> 00:07:50,639
mars 2020 has to seek these signs of

203
00:07:55,189 --> 00:07:53,520
ancient life on mars feeds directly into

204
00:07:57,110 --> 00:07:55,199
this mission's role as a mars sample

205
00:07:59,670 --> 00:07:57,120
return mission and again we'll hear more

206
00:08:01,430 --> 00:07:59,680
about this from mini later on uh but the

207
00:08:05,110 --> 00:08:01,440
the perseverance rover carries with it

208
00:08:07,270 --> 00:08:05,120
43 sample tubes 38 of which are reserved

209
00:08:09,830 --> 00:08:07,280
for rock and regolith samples that the

210
00:08:11,510 --> 00:08:09,840
rover would collect and store

211
00:08:14,230 --> 00:08:11,520
in the rover eventually putting down on

212
00:08:16,469 --> 00:08:14,240
the surface or carrying with it

213
00:08:18,550 --> 00:08:16,479

for for rock and regolith we also carry

214
00:08:20,230 --> 00:08:18,560
with us five witness tubes that can act

215
00:08:21,830 --> 00:08:20,240
as a sort of control

216
00:08:23,749 --> 00:08:21,840
these are tubes that we can seal up at

217
00:08:25,510 --> 00:08:23,759
any time during the mission uh to

218
00:08:28,070 --> 00:08:25,520
essentially characterize the state of

219
00:08:30,070 --> 00:08:28,080
the inside of the rover um for for the

220
00:08:32,149 --> 00:08:30,080
purposes of helping with things like

221
00:08:33,829 --> 00:08:32,159
contamination control and to understand

222
00:08:35,589 --> 00:08:33,839
whether what we're seeing in our samples

223
00:08:37,269 --> 00:08:35,599
when they are eventually turned to earth

224
00:08:39,750 --> 00:08:37,279
does that come from earth does it come

225
00:08:40,389 --> 00:08:39,760
from mars did it come from the rover and

226
00:08:42,469 --> 00:08:40,399
so

227
00:08:45,190 --> 00:08:42,479
this is an important aspect of of the

228
00:08:47,110 --> 00:08:45,200
sample collection uh and preservation

229
00:08:49,190 --> 00:08:47,120
activities that the perseverance rover

230
00:08:50,710 --> 00:08:49,200
has as its prime objectives

231
00:08:52,949 --> 00:08:50,720
so i'll talk a bit about the landing

232
00:08:56,150 --> 00:08:52,959
site uh that perseverance is exploring

233
00:08:57,990 --> 00:08:56,160
and it's a very active field site um the

234
00:09:00,230 --> 00:08:58,000
rover is here in jezreel crater this is

235
00:09:02,389 --> 00:09:00,240
a perspective view of a high-rise image

236
00:09:04,070 --> 00:09:02,399
and perseverance is exploring what we

237
00:09:06,550 --> 00:09:04,080
believe to be one of the best preserved

238
00:09:08,389 --> 00:09:06,560

ancient lake and delta deposits on mars

239
00:09:10,150 --> 00:09:08,399
we were attracted to this site because

240
00:09:12,630 --> 00:09:10,160
it has a diversity of habitable

241
00:09:14,310 --> 00:09:12,640
environments and diverse mineralogy as

242
00:09:16,470 --> 00:09:14,320
observed from orbit

243
00:09:17,990 --> 00:09:16,480
and it provides this really nice about

244
00:09:20,710 --> 00:09:18,000
three and a half to four billion year

245
00:09:22,949 --> 00:09:20,720
old window interplanetary evolution as

246
00:09:25,590 --> 00:09:22,959
it is in some of the oldest crest and

247
00:09:27,110 --> 00:09:25,600
oldest terrain on the surface of mars

248
00:09:29,190 --> 00:09:27,120
but we're

249
00:09:31,269 --> 00:09:29,200
particularly interested in the habitable

250
00:09:34,070 --> 00:09:31,279
environments uh that may be preserved in

251
00:09:35,590 --> 00:09:34,080
jezreel crater and uh there are a number

252
00:09:37,269 --> 00:09:35,600
that we have identified in terms of

253
00:09:38,630 --> 00:09:37,279
general settings in which we think we

254
00:09:40,710 --> 00:09:38,640
may have potential habitable

255
00:09:42,389 --> 00:09:40,720
environments to explore so in the floor

256
00:09:44,230 --> 00:09:42,399
of the crater we have olivine bearing

257
00:09:46,150 --> 00:09:44,240
and mafic igneous rocks they could have

258
00:09:48,230 --> 00:09:46,160
been capable of supporting water rock

259
00:09:49,910 --> 00:09:48,240
interactions and chemical gradients that

260
00:09:52,470 --> 00:09:49,920
might have been supportive of ancient

261
00:09:54,389 --> 00:09:52,480
life of course we have the delta itself

262
00:09:56,230 --> 00:09:54,399
and and we get excited about the distal

263
00:09:58,389 --> 00:09:56,240

rocks of the delta that could include

264
00:10:00,630 --> 00:09:58,399
mudstones or even uh chemical

265
00:10:02,949 --> 00:10:00,640
precipitates deposited within the lake

266
00:10:05,110 --> 00:10:02,959
that would be ideal for biosignature

267
00:10:06,710 --> 00:10:05,120
preservation and then the potential for

268
00:10:08,949 --> 00:10:06,720
the coarse grained rocks as well on the

269
00:10:11,110 --> 00:10:08,959
top surface of the delta representing

270
00:10:12,630 --> 00:10:11,120
higher energy river environments and

271
00:10:13,990 --> 00:10:12,640
while these may not be the best

272
00:10:15,990 --> 00:10:14,000
environments for biosignature

273
00:10:17,590 --> 00:10:16,000
preservation there are the potential for

274
00:10:19,670 --> 00:10:17,600
some micro environments within those

275
00:10:21,990 --> 00:10:19,680
sedimentary rocks as well as hitting on

276
00:10:23,590 --> 00:10:22,000
the diversity aspect bringing in diverse

277
00:10:25,430 --> 00:10:23,600
samples from outside the crater in the

278
00:10:26,949 --> 00:10:25,440
watershed outside jezreel and

279
00:10:29,190 --> 00:10:26,959
concentrating them here in the delta

280
00:10:31,030 --> 00:10:29,200
that the perseverance rover can explore

281
00:10:32,870 --> 00:10:31,040
lastly we have

282
00:10:34,870 --> 00:10:32,880
some margin deposits on the inside of

283
00:10:36,150 --> 00:10:34,880
the crater where we observe carbonates

284
00:10:37,910 --> 00:10:36,160
from orbit and so this is really

285
00:10:39,829 --> 00:10:37,920
exciting because the potential that they

286
00:10:41,670 --> 00:10:39,839
were deposited in shallow lake margin

287
00:10:43,829 --> 00:10:41,680
environments

288
00:10:46,710 --> 00:10:43,839

we haven't yet explored the margins so

289
00:10:48,949 --> 00:10:46,720
my focus today will be on these three

290
00:10:50,389 --> 00:10:48,959
other environments and we'll start off

291
00:10:52,470 --> 00:10:50,399
looking at the coarse grained rocks

292
00:10:54,150 --> 00:10:52,480
actually as these were some of our very

293
00:10:55,509 --> 00:10:54,160
first observations from the surface of

294
00:10:58,230 --> 00:10:55,519
mars

295
00:11:00,870 --> 00:10:58,240
okay so back in february of 2021

296
00:11:03,750 --> 00:11:00,880
perseverance landed here at the octavi

297
00:11:05,750 --> 00:11:03,760
octavia e butler landing on the floor of

298
00:11:07,910 --> 00:11:05,760
jezreel crater so while we were about

299
00:11:10,150 --> 00:11:07,920
two kilometers from the delta which is

300
00:11:12,230 --> 00:11:10,160
one of our main astrobiology targets of

301
00:11:14,389 --> 00:11:12,240
the mission we actually had pretty good

302
00:11:16,310 --> 00:11:14,399
views of the delta and took advantage of

303
00:11:18,310 --> 00:11:16,320
some of our amazing camera capabilities

304
00:11:20,790 --> 00:11:18,320
to see these rocks up close

305
00:11:22,790 --> 00:11:20,800
uh or far away but up close and so we

306
00:11:24,069 --> 00:11:22,800
had some great views of the delta in

307
00:11:26,550 --> 00:11:24,079
particular

308
00:11:28,949 --> 00:11:26,560
looking from our landing site here to

309
00:11:31,350 --> 00:11:28,959
some of the outcrops on the delta front

310
00:11:33,829 --> 00:11:31,360
as well as um in some of these what we

311
00:11:35,910 --> 00:11:33,839
call delta remnants erosional remnants

312
00:11:38,949 --> 00:11:35,920
of what we think is was a past formally

313
00:11:39,829 --> 00:11:38,959

more extensive occurrence of the delta

314
00:11:42,310 --> 00:11:39,839
and so

315
00:11:44,069 --> 00:11:42,320
this past fall we published our first

316
00:11:46,870 --> 00:11:44,079
results from the mission actually coming

317
00:11:49,509 --> 00:11:46,880
from these tel in some cases telescopic

318
00:11:51,350 --> 00:11:49,519
image observations of the delta front

319
00:11:53,430 --> 00:11:51,360
seeing these spectacular boulder

320
00:11:55,509 --> 00:11:53,440
deposits within the upper part of the

321
00:11:57,990 --> 00:11:55,519
jezreel delta now these weren't exactly

322
00:11:59,829 --> 00:11:58,000
expected um we knew there were to expect

323
00:12:01,990 --> 00:11:59,839
delta facies but to see these boulder

324
00:12:04,629 --> 00:12:02,000
beds with up to half a meter to almost a

325
00:12:07,509 --> 00:12:04,639
meter sized boulders i really suggested

326
00:12:10,389 --> 00:12:07,519
suggested an energy regime um and a

327
00:12:12,710 --> 00:12:10,399
float setting that was unexpected and so

328
00:12:14,629 --> 00:12:12,720
we're thinking about the possibility of

329
00:12:17,910 --> 00:12:14,639
a drastic change of environment and

330
00:12:19,990 --> 00:12:17,920
energy conditions and the deposition of

331
00:12:22,949 --> 00:12:20,000
flood deposits essentially in the upper

332
00:12:25,829 --> 00:12:22,959
part of the jezreel delta but of course

333
00:12:28,069 --> 00:12:25,839
we also have classic delta stratigraphy

334
00:12:30,470 --> 00:12:28,079
and this is the kodiak delta remnant

335
00:12:32,870 --> 00:12:30,480
where we see beautiful images of what we

336
00:12:35,110 --> 00:12:32,880
believe to be delta for

337
00:12:37,110 --> 00:12:35,120
top set into four set and into bottom

338
00:12:38,790 --> 00:12:37,120

set beds and from an astrobiology

339
00:12:40,949 --> 00:12:38,800
perspective we get really excited about

340
00:12:43,110 --> 00:12:40,959
the the observation of these bottom set

341
00:12:45,269 --> 00:12:43,120
beds well these are not particularly

342
00:12:47,670 --> 00:12:45,279
accessible by the rover it suggests to

343
00:12:50,310 --> 00:12:47,680
us that elsewhere in the delta will have

344
00:12:52,310 --> 00:12:50,320
the opportunity to explore um beds just

345
00:12:54,230 --> 00:12:52,320
like this

346
00:12:56,389 --> 00:12:54,240
more recent observations

347
00:12:58,389 --> 00:12:56,399
have given us an even greater view as

348
00:13:00,550 --> 00:12:58,399
we've gotten closer to the delta of some

349
00:13:02,949 --> 00:13:00,560
of these spectacular what we think to be

350
00:13:05,110 --> 00:13:02,959
flood deposits and this is a very recent

351
00:13:06,629 --> 00:13:05,120
imaging image coming down from the rover

352
00:13:08,790 --> 00:13:06,639
we're positioned right in front of the

353
00:13:10,470 --> 00:13:08,800
delta and if you look up here at the top

354
00:13:12,230 --> 00:13:10,480
you know we're all focused on the rocks

355
00:13:14,629 --> 00:13:12,240
down here but up at the top this

356
00:13:17,430 --> 00:13:14,639
spectacular boulder deposit

357
00:13:19,269 --> 00:13:17,440
really big meter-sized boulders closely

358
00:13:22,389 --> 00:13:19,279
packed together in contact with one

359
00:13:25,030 --> 00:13:22,399
another and extremely well-rounded and

360
00:13:26,550 --> 00:13:25,040
so this suggests that we have really

361
00:13:28,629 --> 00:13:26,560
high energy floods coming into the

362
00:13:30,550 --> 00:13:28,639
crater depositing these spectacular

363
00:13:32,629 --> 00:13:30,560

boulder deposits and what we're thinking

364
00:13:35,430 --> 00:13:32,639
about now and especially as we seek to

365
00:13:37,829 --> 00:13:35,440
understand the the lake system here in

366
00:13:40,069 --> 00:13:37,839
jezreel is the longevity of these types

367
00:13:41,990 --> 00:13:40,079
of flows and then their intermittency

368
00:13:43,990 --> 00:13:42,000
and this will give us important clues to

369
00:13:45,750 --> 00:13:44,000
the habitability and the evolution of

370
00:13:48,710 --> 00:13:45,760
this habitable lake environment in

371
00:13:50,790 --> 00:13:48,720
jezreel over time okay so now we'll

372
00:13:52,230 --> 00:13:50,800
switch focus that was our our very early

373
00:13:54,870 --> 00:13:52,240
observation it's amazing what we could

374
00:13:56,790 --> 00:13:54,880
get from so far away uh from the delta

375
00:13:59,269 --> 00:13:56,800
uh but now we'll focus on what we

376
00:14:00,150 --> 00:13:59,279
observed in these rocks of the crater

377
00:14:02,069 --> 00:14:00,160
floor

378
00:14:04,230 --> 00:14:02,079
in particular our focus here will be on

379
00:14:06,310 --> 00:14:04,240
aqueous alteration and the potential

380
00:14:08,069 --> 00:14:06,320
water rock interactions that these what

381
00:14:09,829 --> 00:14:08,079
we now know to be igneous rocks have

382
00:14:11,990 --> 00:14:09,839
experienced

383
00:14:13,509 --> 00:14:12,000
okay so we spent the first year of the

384
00:14:15,990 --> 00:14:13,519
mission exploring

385
00:14:16,870 --> 00:14:16,000
uh two major units of the jezer crater

386
00:14:18,230 --> 00:14:16,880
floor

387
00:14:20,069 --> 00:14:18,240
we have the seitan formation which

388
00:14:22,470 --> 00:14:20,079

you'll hear me talk about as well as the

389
00:14:24,230 --> 00:14:22,480
maus formation and the seitan formation

390
00:14:27,110 --> 00:14:24,240
a distinguished cell distinguishes

391
00:14:28,230 --> 00:14:27,120
itself from orbit by being enriched in

392
00:14:29,829 --> 00:14:28,240
olivine

393
00:14:32,389 --> 00:14:29,839
whereas the moss formation has a more

394
00:14:34,710 --> 00:14:32,399
typical mafic composition as observed

395
00:14:36,389 --> 00:14:34,720
from from orbiter spectrometers and so

396
00:14:38,870 --> 00:14:36,399
we were very interested and it was a

397
00:14:41,670 --> 00:14:38,880
fortuitous landing right at the boundary

398
00:14:44,230 --> 00:14:41,680
of what looks to be the major geologic

399
00:14:45,590 --> 00:14:44,240
contact of the crater floor units so

400
00:14:47,750 --> 00:14:45,600
we're interested to understand what

401
00:14:49,829 --> 00:14:47,760
these units were and how they may or may

402
00:14:51,189 --> 00:14:49,839
not be related and for a long time you

403
00:14:52,550 --> 00:14:51,199
know there was a lot of debate on the

404
00:14:53,990 --> 00:14:52,560
science in the science and mars

405
00:14:57,430 --> 00:14:54,000
community about whether these rocks

406
00:14:59,670 --> 00:14:57,440
would be sedimentary volcanic plastic or

407
00:15:02,470 --> 00:14:59,680
or igneous um and we didn't we didn't

408
00:15:04,230 --> 00:15:02,480
know going into the the surface mission

409
00:15:05,990 --> 00:15:04,240
and we continued to be a bit befuddled

410
00:15:07,030 --> 00:15:06,000
for the early part of the mission this

411
00:15:08,629 --> 00:15:07,040
was very

412
00:15:10,310 --> 00:15:08,639
characteristic of the rocks that we saw

413
00:15:12,550 --> 00:15:10,320

on the crater floor they were quite

414
00:15:14,470 --> 00:15:12,560
dusty and as it turned out they had

415
00:15:16,069 --> 00:15:14,480
many of them had a coating on them that

416
00:15:18,550 --> 00:15:16,079
prevented us from actually seeing the

417
00:15:20,069 --> 00:15:18,560
inner texture or fabric of the rocks

418
00:15:22,150 --> 00:15:20,079
so many of the rocks look like this we

419
00:15:24,150 --> 00:15:22,160
call these the pavers

420
00:15:26,629 --> 00:15:24,160
but looking off into the distance we saw

421
00:15:29,749 --> 00:15:26,639
we had these pretty massive apparently

422
00:15:31,110 --> 00:15:29,759
massive looking rocks dark rocks um

423
00:15:32,870 --> 00:15:31,120
and and so we were very much thinking

424
00:15:34,470 --> 00:15:32,880
okay if these are sedimentary rocks what

425
00:15:37,189 --> 00:15:34,480
kind of environments would these massive

426
00:15:39,030 --> 00:15:37,199
rocks represent we're not seeing obvious

427
00:15:41,590 --> 00:15:39,040
a lot of obvious layering maybe here or

428
00:15:43,430 --> 00:15:41,600
there but not really obvious and and no

429
00:15:45,509 --> 00:15:43,440
traction transport bed form structures

430
00:15:47,110 --> 00:15:45,519
or anything like that um and so there

431
00:15:49,269 --> 00:15:47,120
are only certain depositional settings

432
00:15:51,269 --> 00:15:49,279
you could get rocks like that um or

433
00:15:55,670 --> 00:15:51,279
these igneous rocks and could these be

434
00:15:57,670 --> 00:15:55,680
igneous uh basalt the salt lava flows um

435
00:15:59,269 --> 00:15:57,680
we eventually got to this area called

436
00:16:01,110 --> 00:15:59,279
our tube ridge where we started to see

437
00:16:03,189 --> 00:16:01,120
layered rocks and in some cases pretty

438
00:16:05,030 --> 00:16:03,199

fine layering and so this really got us

439
00:16:07,189 --> 00:16:05,040
thinking about well maybe these rocks

440
00:16:09,829 --> 00:16:07,199
could be sedimentary or maybe we have a

441
00:16:12,310 --> 00:16:09,839
mix of sedimentary and volcanic rocks um

442
00:16:14,710 --> 00:16:12,320
but ultimately once we actually got the

443
00:16:16,949 --> 00:16:14,720
ability to abrade these rocks we saw

444
00:16:19,509 --> 00:16:16,959
pretty conclusively that their texture

445
00:16:20,829 --> 00:16:19,519
was characteristic of a hollow

446
00:16:24,389 --> 00:16:20,839
crystalline

447
00:16:27,350 --> 00:16:24,399
um basalt or or even a microgabra where

448
00:16:31,030 --> 00:16:27,360
we have these interlocking crystals of

449
00:16:32,550 --> 00:16:31,040
plagioclase plagioclase and pyroxene um

450
00:16:34,470 --> 00:16:32,560
but interestingly and these are two of

451
00:16:36,710 --> 00:16:34,480
our abrasion patches from some of our

452
00:16:39,269 --> 00:16:36,720
early rocks um in addition to kind of

453
00:16:41,670 --> 00:16:39,279
typical mafic mineralogy we also have

454
00:16:43,910 --> 00:16:41,680
the presence of salt minerals and i'll

455
00:16:47,269 --> 00:16:43,920
show and zoom in here with a spectacular

456
00:16:49,749 --> 00:16:47,279
image from the sherlock aci camera

457
00:16:52,230 --> 00:16:49,759
zooming in on one of these bugs

458
00:16:54,470 --> 00:16:52,240
that is we now know filled with a

459
00:16:55,910 --> 00:16:54,480
sulfate mineral and you know we could be

460
00:16:57,590 --> 00:16:55,920
looking at a thin section here i mean

461
00:17:00,230 --> 00:16:57,600
you can almost even you can you can just

462
00:17:02,629 --> 00:17:00,240
pick out what could be an isopaccis rim

463
00:17:04,470 --> 00:17:02,639

around the inner part of one of these

464
00:17:06,470 --> 00:17:04,480
voids with the sulfate mineral

465
00:17:08,150 --> 00:17:06,480
precipitated inside and so it's

466
00:17:10,150 --> 00:17:08,160
incredible what our cameras and our

467
00:17:12,150 --> 00:17:10,160
geochemistry instruments and mineralogy

468
00:17:14,789 --> 00:17:12,160
instruments can tell us about these

469
00:17:16,789 --> 00:17:14,799
rocks once we're able to abrade them

470
00:17:18,230 --> 00:17:16,799
and so the the presence of these salt

471
00:17:20,230 --> 00:17:18,240
minerals is really exciting and you'll

472
00:17:22,470 --> 00:17:20,240
hear more from lisa mayhew about these

473
00:17:25,189 --> 00:17:22,480
rocks on thursday and their their

474
00:17:27,189 --> 00:17:25,199
astrobiological potential um but we get

475
00:17:28,470 --> 00:17:27,199
really excited about the presence of

476
00:17:31,110 --> 00:17:28,480
these salts and i'll show you in this

477
00:17:33,270 --> 00:17:31,120
next slide a nice pixel map overlaid on

478
00:17:36,230 --> 00:17:33,280
top showing yes indeed we do have the

479
00:17:38,070 --> 00:17:36,240
sulfates popping out here in this rock

480
00:17:39,190 --> 00:17:38,080
um because

481
00:17:41,190 --> 00:17:39,200
even though

482
00:17:43,270 --> 00:17:41,200
we still have the the primary igneous

483
00:17:44,950 --> 00:17:43,280
mineralogy present in these rocks we

484
00:17:46,950 --> 00:17:44,960
don't have abundant aluminum clay

485
00:17:49,909 --> 00:17:46,960
suggesting relatively low water rock

486
00:17:51,990 --> 00:17:49,919
ratio likely in a closed system

487
00:17:53,909 --> 00:17:52,000
it's still abundantly clear that water

488
00:17:55,750 --> 00:17:53,919

interacted with these rocks moved

489
00:17:57,990 --> 00:17:55,760
through these rocks altered them altered

490
00:18:00,470 --> 00:17:58,000
the minerals primary mineralogy as well

491
00:18:02,390 --> 00:18:00,480
as depositing these uh

492
00:18:04,310 --> 00:18:02,400
evaporate precipitates within within the

493
00:18:06,150 --> 00:18:04,320
rocks and so this is really exciting

494
00:18:08,070 --> 00:18:06,160
from an astrobiology perspective

495
00:18:10,230 --> 00:18:08,080
thinking about the micro niches that

496
00:18:13,029 --> 00:18:10,240
might have formed as water interacted

497
00:18:14,630 --> 00:18:13,039
with these primary minerals

498
00:18:16,870 --> 00:18:14,640
okay so that was our

499
00:18:18,789 --> 00:18:16,880
our exploration of the mafic rocks of

500
00:18:20,630 --> 00:18:18,799
the moz formation but then we had the

501
00:18:22,470 --> 00:18:20,640
opportunity to cross into this other

502
00:18:24,630 --> 00:18:22,480
unit the seitan formation and this is

503
00:18:26,230 --> 00:18:24,640
the olivine bearing unit we didn't quite

504
00:18:28,070 --> 00:18:26,240
know again the origin of this you know

505
00:18:29,990 --> 00:18:28,080
olivine bearing rocks are kind of

506
00:18:31,909 --> 00:18:30,000
unusual here on earth and so what was

507
00:18:33,270 --> 00:18:31,919
this going to be like on mars and so

508
00:18:36,230 --> 00:18:33,280
when we had the opportunity to look at

509
00:18:37,430 --> 00:18:36,240
these rocks up close really astounded by

510
00:18:39,110 --> 00:18:37,440
the texture of them where we could

511
00:18:41,430 --> 00:18:39,120
actually pick out these individual

512
00:18:43,029 --> 00:18:41,440
clasts that didn't did indeed turn out

513
00:18:44,470 --> 00:18:43,039

to be olivine we were starting to think

514
00:18:48,070 --> 00:18:44,480
you know is this some kind of ultra

515
00:18:50,150 --> 00:18:48,080
mafic ash are these clastic rocks um

516
00:18:52,310 --> 00:18:50,160
but again the opportunity to abrade and

517
00:18:54,470 --> 00:18:52,320
use our proximity science instruments

518
00:18:56,470 --> 00:18:54,480
pixel and sherlock really helped put to

519
00:18:59,110 --> 00:18:56,480
bed any questions about the origin of

520
00:19:01,190 --> 00:18:59,120
these rocks i'll show next a a scan from

521
00:19:03,029 --> 00:19:01,200
the pixel instrument

522
00:19:04,950 --> 00:19:03,039
showing a beautiful example of a

523
00:19:06,630 --> 00:19:04,960
poicolytic texture here where you have

524
00:19:07,590 --> 00:19:06,640
an olivine

525
00:19:09,830 --> 00:19:07,600
grain

526
00:19:12,150 --> 00:19:09,840
completely surrounded by a pyroxene

527
00:19:15,350 --> 00:19:12,160
grain so pretty much a slam dunk here

528
00:19:17,270 --> 00:19:15,360
that these are igneous rocks formed from

529
00:19:19,830 --> 00:19:17,280
a magma so we're looking at here

530
00:19:21,830 --> 00:19:19,840
essentially an olivine cumulate here in

531
00:19:24,470 --> 00:19:21,840
jezreel crater also the crater that we

532
00:19:25,990 --> 00:19:24,480
have a lake basin in and so this really

533
00:19:28,150 --> 00:19:26,000
got us thinking you know what is the

534
00:19:29,990 --> 00:19:28,160
what is the geologic context here that

535
00:19:32,470 --> 00:19:30,000
would put an olivine cumulative inside

536
00:19:35,750 --> 00:19:32,480
this crater and so we're considering the

537
00:19:38,310 --> 00:19:35,760
possibility of a magmatic intrusion or

538
00:19:39,830 --> 00:19:38,320

the possibility of perhaps a deep lava

539
00:19:41,190 --> 00:19:39,840
lake um

540
00:19:43,430 --> 00:19:41,200
and then what is the relationship

541
00:19:45,350 --> 00:19:43,440
between these rocks and the more mafic

542
00:19:47,750 --> 00:19:45,360
rocks are we looking at the the

543
00:19:49,590 --> 00:19:47,760
differentiation of a single magma body

544
00:19:52,310 --> 00:19:49,600
or an olivine accumulate with a much

545
00:19:53,830 --> 00:19:52,320
later basalt coming in on top so still

546
00:19:56,310 --> 00:19:53,840
some outstanding questions here in the

547
00:19:58,390 --> 00:19:56,320
origin but clearly a diversity of

548
00:20:00,470 --> 00:19:58,400
igneous rocks which gives us great

549
00:20:02,390 --> 00:20:00,480
insight into what's happening in the

550
00:20:03,830 --> 00:20:02,400
interior of mars so really exciting to

551
00:20:04,950 --> 00:20:03,840
have the opportunity to explore these

552
00:20:07,270 --> 00:20:04,960
rocks

553
00:20:09,669 --> 00:20:07,280
okay so in addition as i mentioned

554
00:20:11,430 --> 00:20:09,679
the primary igneous mineralogy also had

555
00:20:14,149 --> 00:20:11,440
the opportunity to to discover that

556
00:20:15,750 --> 00:20:14,159
these rocks have these um

557
00:20:17,990 --> 00:20:15,760
carbonate and sulfate minerals and so

558
00:20:19,590 --> 00:20:18,000
this is a sherlock point map

559
00:20:21,830 --> 00:20:19,600
showing that we have the olivine

560
00:20:24,390 --> 00:20:21,840
crystals here in green um but anywhere

561
00:20:25,510 --> 00:20:24,400
you see blue is is carbonate and so

562
00:20:27,990 --> 00:20:25,520
really exciting that we have the

563
00:20:30,230 --> 00:20:28,000

alteration of olivine to carbonate in

564
00:20:32,070 --> 00:20:30,240
along these grain boundaries um and what

565
00:20:35,110 --> 00:20:32,080
we also see with sherlock and sananda

566
00:20:37,029 --> 00:20:35,120
sharma talked about this yesterday but

567
00:20:39,590 --> 00:20:37,039
correlating with these carbonate and

568
00:20:41,669 --> 00:20:39,600
sulfate minerals are organic detections

569
00:20:43,590 --> 00:20:41,679
so these are one and two ring relatively

570
00:20:46,070 --> 00:20:43,600
simple organics uh but their

571
00:20:48,230 --> 00:20:46,080
co-occurrence with these carbonate and

572
00:20:50,789 --> 00:20:48,240
sulfate minerals suggested the organic

573
00:20:52,310 --> 00:20:50,799
formation may have been related to the

574
00:20:54,789 --> 00:20:52,320
interaction of

575
00:20:56,950 --> 00:20:54,799
these minerals with water at their grain

576
00:20:58,950 --> 00:20:56,960
boundaries so again really exciting for

577
00:21:01,270 --> 00:20:58,960
the potential for habitable niches at

578
00:21:03,350 --> 00:21:01,280
these very specific micro environments

579
00:21:05,110 --> 00:21:03,360
within igneous rocks which otherwise may

580
00:21:07,510 --> 00:21:05,120
not have really been our prime

581
00:21:09,669 --> 00:21:07,520
astrobiology target um

582
00:21:10,870 --> 00:21:09,679
the great potential here for these rocks

583
00:21:12,789 --> 00:21:10,880
and

584
00:21:15,669 --> 00:21:12,799
these igneous rock this diverse suite of

585
00:21:17,909 --> 00:21:15,679
igneous rocks makes up at this point

586
00:21:21,430 --> 00:21:17,919
the eight rock samples that we've

587
00:21:23,430 --> 00:21:21,440
currently put in the perseverance cache

588
00:21:25,669 --> 00:21:23,440

okay so i'll wrap up here with just a

589
00:21:27,669 --> 00:21:25,679
taste of what the rover is looking at

590
00:21:29,350 --> 00:21:27,679
right now and what we have ahead of us

591
00:21:31,029 --> 00:21:29,360
so we will return a bit to the

592
00:21:32,710 --> 00:21:31,039
coarse-grained rocks that we may have

593
00:21:34,390 --> 00:21:32,720
present in the delta but also start

594
00:21:35,990 --> 00:21:34,400
thinking about some of these distal

595
00:21:37,590 --> 00:21:36,000
rocks that might have been deposited in

596
00:21:40,230 --> 00:21:37,600
this lake basin

597
00:21:43,029 --> 00:21:40,240
um so the rover is is here right now

598
00:21:45,909 --> 00:21:43,039
this is the the front of the delta

599
00:21:47,190 --> 00:21:45,919
and we arrived at the delta after a long

600
00:21:49,350 --> 00:21:47,200
journey

601
00:21:50,630 --> 00:21:49,360
that took us about a month and a half

602
00:21:52,230 --> 00:21:50,640
and we arrived here in front of the

603
00:21:53,830 --> 00:21:52,240
delta these are the delta sediments

604
00:21:56,710 --> 00:21:53,840
right here these are the rocks of the

605
00:21:58,950 --> 00:21:56,720
crater floor and we did a loop here um

606
00:22:00,310 --> 00:21:58,960
in an area called cannery passage and in

607
00:22:03,029 --> 00:22:00,320
a couple of slides i'll show you some

608
00:22:04,870 --> 00:22:03,039
images right from here um and the rover

609
00:22:07,750 --> 00:22:04,880
has has since worked its way over and

610
00:22:09,669 --> 00:22:07,760
just yesterday arrived right here but

611
00:22:11,669 --> 00:22:09,679
i'll show you some images here and what

612
00:22:14,470 --> 00:22:11,679
are the first sedimentary rocks observed

613
00:22:16,630 --> 00:22:14,480

by perseverance and so this is the view

614
00:22:18,390 --> 00:22:16,640
of that same area on the ground

615
00:22:20,789 --> 00:22:18,400
beautiful landscape view this is the

616
00:22:22,549 --> 00:22:20,799
cape nook shack area this is hawksville

617
00:22:24,710 --> 00:22:22,559
gap where the rover is currently sitting

618
00:22:26,630 --> 00:22:24,720
somewhere over here and that area we'll

619
00:22:28,710 --> 00:22:26,640
zoom into is over here right at the base

620
00:22:31,190 --> 00:22:28,720
of this delta section

621
00:22:33,110 --> 00:22:31,200
and so this was one of our first views

622
00:22:35,590 --> 00:22:33,120
of an area that we called enchanted lake

623
00:22:37,669 --> 00:22:35,600
perhaps optimistically hoping to find uh

624
00:22:39,110 --> 00:22:37,679
what we wanted to find here and indeed

625
00:22:40,549 --> 00:22:39,120
we believe these are the first

626
00:22:43,029 --> 00:22:40,559
sedimentary rocks encountered by

627
00:22:44,870 --> 00:22:43,039
perseverance so we'll zoom in here this

628
00:22:46,710 --> 00:22:44,880
is a sandstone what we now know to be a

629
00:22:48,549 --> 00:22:46,720
sandstone forms the base of this

630
00:22:50,470 --> 00:22:48,559
enchanted lake outcrop it has a

631
00:22:53,350 --> 00:22:50,480
composition very similar to the sata

632
00:22:55,750 --> 00:22:53,360
rocks but it is not seita instead we see

633
00:22:57,669 --> 00:22:55,760
very clear uh cross betting here in

634
00:23:00,470 --> 00:22:57,679
particular low angle scour and drape

635
00:23:03,430 --> 00:23:00,480
geometry um suggesting that these might

636
00:23:05,830 --> 00:23:03,440
be related to some kind of um

637
00:23:08,310 --> 00:23:05,840
either fluvial processes or subaqueous

638
00:23:10,710 --> 00:23:08,320

channel deposit when we zoom in with the

639
00:23:12,789 --> 00:23:10,720
supercam rmi imager we can actually

640
00:23:13,990 --> 00:23:12,799
resolve um small grains i don't have a

641
00:23:15,190 --> 00:23:14,000
scale here but these are a couple

642
00:23:16,950 --> 00:23:15,200
millimeters

643
00:23:18,789 --> 00:23:16,960
in diameter suggesting that they were

644
00:23:20,630 --> 00:23:18,799
not deposited by the wind and that we

645
00:23:22,950 --> 00:23:20,640
are very clearly looking at a subaqueous

646
00:23:24,630 --> 00:23:22,960
deposit so entirely consistent with the

647
00:23:26,310 --> 00:23:24,640
delta setting but what got our

648
00:23:28,310 --> 00:23:26,320
scientists really excited were these

649
00:23:31,270 --> 00:23:28,320
potentially fine-grained planar

650
00:23:33,830 --> 00:23:31,280
laminated deposits above that sandstone

651
00:23:35,590 --> 00:23:33,840
thinking that these could be the

652
00:23:37,590 --> 00:23:35,600
the distal lake beds or delta bottom

653
00:23:40,070 --> 00:23:37,600
said beds that we are so excited to

654
00:23:41,830 --> 00:23:40,080
explore here at the delta

655
00:23:44,070 --> 00:23:41,840
and so this is just the beginning of our

656
00:23:46,310 --> 00:23:44,080
exploration of the delta and so much

657
00:23:48,070 --> 00:23:46,320
more to come here we pretty much wrapped

658
00:23:50,630 --> 00:23:48,080
up our exploration of the crater floor

659
00:23:52,470 --> 00:23:50,640
are in progress of exploring the distal

660
00:23:55,350 --> 00:23:52,480
and and more proximal deposits of the

661
00:23:57,909 --> 00:23:55,360
delta and have to look ahead of uh

662
00:23:59,750 --> 00:23:57,919
toward the explanation of the carbonates

663
00:24:01,269 --> 00:23:59,760

along the margin in the future and so

664
00:24:03,909 --> 00:24:01,279
i'll wrap up here with just putting up

665
00:24:06,149 --> 00:24:03,919
our our current sample cache

666
00:24:08,149 --> 00:24:06,159
a diverse suite of igneous rocks thus

667
00:24:10,549 --> 00:24:08,159
far collected and we hope to fill in

668
00:24:12,149 --> 00:24:10,559
these empty rows here with a diverse

669
00:24:14,310 --> 00:24:12,159
suite of interesting and

670
00:24:15,990 --> 00:24:14,320
astrobiologically compelling sedimentary

671
00:24:25,350 --> 00:24:16,000
samples so i'll wind up here and happy

672
00:24:30,390 --> 00:24:28,070
okay we actually have a question from

673
00:24:32,390 --> 00:24:30,400
online from ben pierce what is the

674
00:24:36,070 --> 00:24:32,400
proposed formation mechanism for the

675
00:24:37,750 --> 00:24:36,080
boulders you found in the jezreel crater

676
00:24:38,870 --> 00:24:37,760
yeah that's a great question i think the

677
00:24:40,870 --> 00:24:38,880
first

678
00:24:42,149 --> 00:24:40,880
interpretation we had for them were that

679
00:24:43,750 --> 00:24:42,159
they were

680
00:24:47,269 --> 00:24:43,760
high-energy floods coming into the

681
00:24:50,070 --> 00:24:47,279
crater perhaps related to some upstream

682
00:24:52,390 --> 00:24:50,080
process it could be release a melting of

683
00:24:54,549 --> 00:24:52,400
a glacial dam or something like that

684
00:24:57,110 --> 00:24:54,559
that caused a catastrophic flow into the

685
00:24:59,029 --> 00:24:57,120
crater however our very recent

686
00:25:00,630 --> 00:24:59,039
observations suggest that we might

687
00:25:03,190 --> 00:25:00,640
actually be seeing more of these boulder

688
00:25:05,430 --> 00:25:03,200

beds interbedded with some of our

689
00:25:07,269 --> 00:25:05,440
finer grained lower energy sedimentary

690
00:25:08,870 --> 00:25:07,279
deposits suggesting that we might

691
00:25:10,950 --> 00:25:08,880
actually be looking at something more

692
00:25:13,269 --> 00:25:10,960
like sheep floods and it may be a more

693
00:25:15,269 --> 00:25:13,279
common but intermittent process

694
00:25:22,870 --> 00:25:15,279
depositing those those boulders in that

695
00:25:22,880 --> 00:25:25,909
question

696
00:25:30,870 --> 00:25:28,390
let's uh let's let's uh thank let's save

697
00:25:33,510 --> 00:25:30,880
our time for the broader discussion

698
00:25:41,510 --> 00:25:33,520
afterward in that case and um uh but

699
00:25:43,830 --> 00:25:42,710
and and she'll be back for the

700
00:25:46,470 --> 00:25:43,840
discussion

701
00:25:48,870 --> 00:25:46,480
uh at the end of the session um but uh

702
00:25:52,710 --> 00:25:48,880
next uh i'd like to introduce

703
00:25:55,350 --> 00:25:52,720
professor minakshi wadwa

704
00:25:56,549 --> 00:25:55,360
mini is a planetary scientist and

705
00:25:58,710 --> 00:25:56,559
isotope

706
00:26:00,950 --> 00:25:58,720
cosmochemist interested in the time

707
00:26:03,350 --> 00:26:00,960
scales and processes involved in the

708
00:26:06,549 --> 00:26:03,360
formation and evolution of the solar

709
00:26:07,909 --> 00:26:06,559
system and planets

710
00:26:09,830 --> 00:26:07,919
she received her doctorate from

711
00:26:12,149 --> 00:26:09,840
washington university in st louis and

712
00:26:14,390 --> 00:26:12,159
was a post-doctoral researcher

713
00:26:15,430 --> 00:26:14,400

at the university of california at san

714
00:26:17,510 --> 00:26:15,440
diego

715
00:26:19,350 --> 00:26:17,520
she was subsequently curator in the

716
00:26:21,269 --> 00:26:19,360
department of geology at the field

717
00:26:23,750 --> 00:26:21,279
museum in chicago before moving to

718
00:26:25,510 --> 00:26:23,760
arizona state university where she is

719
00:26:27,510 --> 00:26:25,520
professor in the school of earth and

720
00:26:29,590 --> 00:26:27,520
space exploration

721
00:26:30,870 --> 00:26:29,600
and additionally serves as the director

722
00:26:32,710 --> 00:26:30,880
of the school

723
00:26:35,269 --> 00:26:32,720
she's appointed as a distinguished

724
00:26:37,590 --> 00:26:35,279
visiting scientist

725
00:26:39,750 --> 00:26:37,600
and mars sample return principal

726
00:26:41,029 --> 00:26:39,760
scientist at the jet propulsion

727
00:26:43,029 --> 00:26:41,039
laboratory

728
00:26:45,510 --> 00:26:43,039
she's the recipient of numerous awards

729
00:26:48,149 --> 00:26:45,520
including the j lawrence smith medal of

730
00:26:50,950 --> 00:26:48,159
the national academy of sciences

731
00:26:52,470 --> 00:26:50,960
and she became a fellow of the american

732
00:26:54,870 --> 00:26:52,480
geophysical union

733
00:26:56,269 --> 00:26:54,880
in 2019.

734
00:27:00,470 --> 00:26:56,279
asteroid

735
00:27:02,789 --> 00:27:00,480
8356 has been named 8356 wadwa in

736
00:27:05,750 --> 00:27:02,799
recognition of her contributions to

737
00:27:08,149 --> 00:27:05,760
meteoritics and planetary sciences

738
00:27:17,029 --> 00:27:08,159

thank you minnie for joining us today to

739
00:27:21,110 --> 00:27:19,190
all right well thanks so much for this

740
00:27:23,669 --> 00:27:21,120
great introduction i'm so pleased to be

741
00:27:32,630 --> 00:27:25,190
so

742
00:27:32,640 --> 00:27:38,950
are we all set

743
00:27:38,960 --> 00:27:42,470
oh okay got it

744
00:27:42,480 --> 00:27:51,990
oh i see i see sorry about that

745
00:27:54,870 --> 00:27:54,070
okay all right well

746
00:27:56,230 --> 00:27:54,880
so

747
00:27:57,830 --> 00:27:56,240
i'm going to be telling you a little bit

748
00:27:59,830 --> 00:27:57,840
about

749
00:28:01,430 --> 00:27:59,840
martian samples

750
00:28:03,750 --> 00:28:01,440
and

751
00:28:05,669 --> 00:28:03,760
at least at the current time the only

752
00:28:08,230 --> 00:28:05,679
martian samples that we currently have

753
00:28:09,430 --> 00:28:08,240
are the ones that come to us as

754
00:28:11,669 --> 00:28:09,440
meteorites

755
00:28:13,430 --> 00:28:11,679
and so i'm going to start out with what

756
00:28:14,710 --> 00:28:13,440
we can learn about the astrobiological

757
00:28:17,029 --> 00:28:14,720
potential

758
00:28:20,389 --> 00:28:17,039
of mars through studies of those types

759
00:28:22,630 --> 00:28:20,399
of materials and then transition over to

760
00:28:24,389 --> 00:28:22,640
talking about the plans that we have for

761
00:28:26,310 --> 00:28:24,399
bringing actual samples back from the

762
00:28:28,549 --> 00:28:26,320
crust of mars

763
00:28:30,789 --> 00:28:28,559

that katie just talked about is

764
00:28:33,110 --> 00:28:30,799
basically the first stage of doing that

765
00:28:34,070 --> 00:28:33,120
mars 2020 has already begun that process

766
00:28:36,389 --> 00:28:34,080
and so

767
00:28:38,870 --> 00:28:36,399
um i'm going to start first with talking

768
00:28:41,269 --> 00:28:38,880
about martian meteorites so mars

769
00:28:43,430 --> 00:28:41,279
meteorites are really um

770
00:28:46,470 --> 00:28:43,440
really close to my heart i actually

771
00:28:47,830 --> 00:28:46,480
started my graduate career starting

772
00:28:49,590 --> 00:28:47,840
starting out as a graduate student

773
00:28:51,350 --> 00:28:49,600
studying these materials and in fact

774
00:28:52,950 --> 00:28:51,360
that's really what kind of drew me to

775
00:28:55,430 --> 00:28:52,960
the study of meteorites and cosmic

776
00:28:57,830 --> 00:28:55,440
chemistry because i had absolutely no

777
00:29:00,470 --> 00:28:57,840
idea that we actually had samples that

778
00:29:02,230 --> 00:29:00,480
we think came from the crust of mars

779
00:29:04,549 --> 00:29:02,240
here on earth it was just it just blew

780
00:29:07,990 --> 00:29:04,559
my mind when i kind of learned that and

781
00:29:09,750 --> 00:29:08,000
i was totally hooked from that point on

782
00:29:11,430 --> 00:29:09,760
at that time when i started actually

783
00:29:13,029 --> 00:29:11,440
studying these martian meteorites there

784
00:29:14,950 --> 00:29:13,039
were literally just a handful of these

785
00:29:17,350 --> 00:29:14,960
rocks that we knew about but just in

786
00:29:19,269 --> 00:29:17,360
these last couple of decades

787
00:29:20,710 --> 00:29:19,279
there have been many many more

788
00:29:23,029 --> 00:29:20,720

meteorites that have been collected in

789
00:29:25,110 --> 00:29:23,039
antarctica as well as in the desert

790
00:29:26,389 --> 00:29:25,120
regions of the world saharan deserts in

791
00:29:29,190 --> 00:29:26,399
particular

792
00:29:32,149 --> 00:29:29,200
and at the current time we believe uh

793
00:29:34,070 --> 00:29:32,159
there are about 178 that we can count

794
00:29:37,029 --> 00:29:34,080
that are distinct martian meteorites not

795
00:29:40,630 --> 00:29:37,039
paired samples but distinct samples that

796
00:29:43,029 --> 00:29:40,640
we think came from the planet mars

797
00:29:45,430 --> 00:29:43,039
all except one of them

798
00:29:47,430 --> 00:29:45,440
and this is known as the northwest

799
00:29:49,590 --> 00:29:47,440
africa 7034

800
00:29:52,070 --> 00:29:49,600
also known as black beauty there's only

801
00:29:54,870 --> 00:29:52,080
one that is not an igneous rock all

802
00:29:59,190 --> 00:29:54,880
others are igneous rocks that date to

803
00:30:00,630 --> 00:29:59,200
about 4.1 to about 150 million years

804
00:30:02,310 --> 00:30:00,640
so

805
00:30:03,909 --> 00:30:02,320
these are all primarily igneous

806
00:30:05,590 --> 00:30:03,919
materials and and you can see here on

807
00:30:09,430 --> 00:30:05,600
the slide

808
00:30:11,590 --> 00:30:09,440
basically the the data that

809
00:30:13,830 --> 00:30:11,600
was acquired many many decades ago now

810
00:30:15,669 --> 00:30:13,840
but which really firmly established for

811
00:30:17,590 --> 00:30:15,679
the first time that these rocks indeed

812
00:30:21,350 --> 00:30:17,600
come from the planet mars and that's

813
00:30:24,070 --> 00:30:21,360

basically this graph that shows

814
00:30:26,110 --> 00:30:24,080
gases that were released uh from this

815
00:30:29,190 --> 00:30:26,120
particular meteorite

816
00:30:31,110 --> 00:30:29,200
eet79001 it was one of the first

817
00:30:34,470 --> 00:30:31,120
meteorites that was actually collected

818
00:30:36,630 --> 00:30:34,480
in antarctica uh part of the 79 1979

819
00:30:38,870 --> 00:30:36,640
field season and

820
00:30:40,710 --> 00:30:38,880
it actually contains these uh impact

821
00:30:42,149 --> 00:30:40,720
milk classes that if these when these

822
00:30:44,310 --> 00:30:42,159
are heated up they actually release

823
00:30:45,990 --> 00:30:44,320
gases which when compared to the martian

824
00:30:48,070 --> 00:30:46,000
atmosphere which had been measured

825
00:30:48,830 --> 00:30:48,080
fairly recently at that time this is in

826
00:30:53,350 --> 00:30:48,840
the

827
00:30:55,269 --> 00:30:53,360
see this really beautiful one-to-one

828
00:30:56,149 --> 00:30:55,279
correlation which really kind of helps

829
00:30:57,990 --> 00:30:56,159
to

830
00:30:59,750 --> 00:30:58,000
pinpoint a martian origin for these

831
00:31:02,310 --> 00:30:59,760
rocks and then of course the oxidized

832
00:31:04,950 --> 00:31:02,320
compositions of all of these rocks all

833
00:31:07,029 --> 00:31:04,960
align along a single slope half line

834
00:31:08,789 --> 00:31:07,039
that's different from that of the earth

835
00:31:11,990 --> 00:31:08,799
and other meteorites and so we can

836
00:31:13,830 --> 00:31:12,000
connect them all together and um

837
00:31:15,990 --> 00:31:13,840
indicate that in fact these rocks

838
00:31:17,350 --> 00:31:16,000

actually came from mars and so

839
00:31:19,029 --> 00:31:17,360
this is just to show you sort of the

840
00:31:20,870 --> 00:31:19,039
diversity of materials that we think

841
00:31:23,110 --> 00:31:20,880
come from ours in terms of their igneous

842
00:31:25,029 --> 00:31:23,120
textures and as i mentioned primarily

843
00:31:27,909 --> 00:31:25,039
most of these things are igneous rocks

844
00:31:29,430 --> 00:31:27,919
177 of them of the 178 that i just

845
00:31:31,509 --> 00:31:29,440
mentioned are igneous rocks and you can

846
00:31:33,509 --> 00:31:31,519
see all the different types of of

847
00:31:34,789 --> 00:31:33,519
textures ranging from

848
00:31:37,590 --> 00:31:34,799
um

849
00:31:40,070 --> 00:31:37,600
basically basaltic materials

850
00:31:41,750 --> 00:31:40,080
mostly plagioclase pyroxene with some

851
00:31:43,590 --> 00:31:41,760
olivine in there some of the same kinds

852
00:31:45,190 --> 00:31:43,600
of textures that katie was talking about

853
00:31:47,029 --> 00:31:45,200
the portalytic textures you can see

854
00:31:49,909 --> 00:31:47,039
those in the in the ones that we call

855
00:31:52,149 --> 00:31:49,919
sugar tights for example and then on the

856
00:31:55,350 --> 00:31:52,159
left hand side you can see

857
00:31:57,190 --> 00:31:55,360
a planer peroxinite the naclites

858
00:32:01,269 --> 00:31:57,200
and these are cumulate rocks that are

859
00:32:03,909 --> 00:32:01,279
primarily made up of uh agite pyroxenes

860
00:32:07,149 --> 00:32:03,919
and then on the lower left hand side you

861
00:32:09,190 --> 00:32:07,159
can see the allen hills 8401

862
00:32:11,190 --> 00:32:09,200
orthopyroxenite which of course many of

863
00:32:13,509 --> 00:32:11,200

you probably have already heard about

864
00:32:16,710 --> 00:32:13,519
that rock which was the one that uh the

865
00:32:18,389 --> 00:32:16,720
1996 study by mckay it all had proposed

866
00:32:20,310 --> 00:32:18,399
that there was evidence of past biogenic

867
00:32:22,310 --> 00:32:20,320
life in this rock but we'll get to that

868
00:32:23,909 --> 00:32:22,320
in just a minute but uh all of these

869
00:32:26,630 --> 00:32:23,919
arrangements materials have you know

870
00:32:29,110 --> 00:32:26,640
igneous textures um as i mentioned they

871
00:32:30,870 --> 00:32:29,120
range in ages from about 150

872
00:32:34,230 --> 00:32:30,880
million years or so for the youngest

873
00:32:36,389 --> 00:32:34,240
surgice to about 4.1 billion years for

874
00:32:39,909 --> 00:32:36,399
the alh eight four zero zero one

875
00:32:42,549 --> 00:32:39,919
orthoperoxide and then there's this one

876
00:32:45,190 --> 00:32:42,559
regolith breccia the 7034 that's shown

877
00:32:46,950 --> 00:32:45,200
on the lower right which

878
00:32:49,669 --> 00:32:46,960
is actually

879
00:32:51,990 --> 00:32:49,679
an agglomeration of of different clasts

880
00:32:54,470 --> 00:32:52,000
that are some of them are actually

881
00:32:57,029 --> 00:32:54,480
described as sedimentary but really what

882
00:32:59,909 --> 00:32:57,039
they are are proto brushes they're class

883
00:33:00,710 --> 00:32:59,919
that have we think could have been um

884
00:33:03,509 --> 00:33:00,720
either

885
00:33:06,389 --> 00:33:03,519
produced by impact melts or perhaps

886
00:33:07,830 --> 00:33:06,399
some kind of pyroclastic deposits

887
00:33:10,389 --> 00:33:07,840
and possibly some some sort of

888
00:33:12,149 --> 00:33:10,399

sedimentological process as well so

889
00:33:13,909 --> 00:33:12,159
this is a very interesting rock it's got

890
00:33:16,549 --> 00:33:13,919
probably it's got the most amount of

891
00:33:18,149 --> 00:33:16,559
water bulk abundance of water of any of

892
00:33:20,789 --> 00:33:18,159
the martian meteorites about one weight

893
00:33:22,310 --> 00:33:20,799
percent or so

894
00:33:25,430 --> 00:33:22,320
so

895
00:33:26,389 --> 00:33:25,440
martian samples that are available for

896
00:33:28,149 --> 00:33:26,399
study

897
00:33:30,549 --> 00:33:28,159
as i mentioned most of them are igneous

898
00:33:32,070 --> 00:33:30,559
rocks but from the astrobiological

899
00:33:35,750 --> 00:33:32,080
perspective

900
00:33:37,750 --> 00:33:35,760
there are i would say three particular

901
00:33:39,190 --> 00:33:37,760
types of of these

902
00:33:41,029 --> 00:33:39,200
meteoritic materials that are of

903
00:33:42,470 --> 00:33:41,039
interest and

904
00:33:44,389 --> 00:33:42,480
what i'm going to do next is basically

905
00:33:45,830 --> 00:33:44,399
just tell you a little bit about and i'm

906
00:33:47,590 --> 00:33:45,840
this is not going to be comprehensive by

907
00:33:51,669 --> 00:33:47,600
any means but i'll give examples of the

908
00:33:54,389 --> 00:33:51,679
kinds of things that have provided some

909
00:33:56,230 --> 00:33:54,399
basis for of gauging the astrobiological

910
00:33:58,470 --> 00:33:56,240
potential of mars based on these types

911
00:33:59,990 --> 00:33:58,480
of materials so the kinds of materials

912
00:34:02,070 --> 00:34:00,000
that are interesting from from the

913
00:34:04,389 --> 00:34:02,080

meteoritic collection number one you

914
00:34:07,190 --> 00:34:04,399
have igneous martian meteorites that

915
00:34:08,470 --> 00:34:07,200
show clear evidence of alteration

916
00:34:11,349 --> 00:34:08,480
um

917
00:34:13,109 --> 00:34:11,359
caused by fluids on mars and so you have

918
00:34:15,030 --> 00:34:13,119
materials such as eating site and the

919
00:34:18,230 --> 00:34:15,040
naclites

920
00:34:20,310 --> 00:34:18,240
carbonates in alh 84001

921
00:34:22,310 --> 00:34:20,320
so these are all uh

922
00:34:24,629 --> 00:34:22,320
materials that were secondary alteration

923
00:34:26,550 --> 00:34:24,639
products produced as a result of

924
00:34:29,270 --> 00:34:26,560
interaction with either aqueous or

925
00:34:30,950 --> 00:34:29,280
hydrothermal fluids on on the surface of

926
00:34:33,109 --> 00:34:30,960
mars

927
00:34:34,869 --> 00:34:33,119
the second one of course is this unique

928
00:34:37,589 --> 00:34:34,879
regolith pressure in northwest africa

929
00:34:39,750 --> 00:34:37,599
1734 and as i mentioned this has about

930
00:34:41,270 --> 00:34:39,760
the highest bulk abundance of water of

931
00:34:43,109 --> 00:34:41,280
any of the known martian meteorites

932
00:34:45,990 --> 00:34:43,119
about one weight percent or so as

933
00:34:48,310 --> 00:34:46,000
determined by um carl again colleagues

934
00:34:50,149 --> 00:34:48,320
in a paper that was published almost a

935
00:34:52,230 --> 00:34:50,159
decade ago now

936
00:34:55,030 --> 00:34:52,240
and then as i mentioned also presence of

937
00:34:56,629 --> 00:34:55,040
some some sedimentary class as well so

938
00:34:58,390 --> 00:34:56,639

it's not all igneous materials

939
00:35:00,630 --> 00:34:58,400
purportedly

940
00:35:03,109 --> 00:35:00,640
and then the one

941
00:35:05,829 --> 00:35:03,119
martian meteorite that is also of

942
00:35:08,870 --> 00:35:05,839
interest is one that is the freshest of

943
00:35:10,390 --> 00:35:08,880
the fall so among the 178 meteorites

944
00:35:12,310 --> 00:35:10,400
that i just talked about there are only

945
00:35:14,470 --> 00:35:12,320
five literally just five that are

946
00:35:16,069 --> 00:35:14,480
observed falls and these are of course

947
00:35:17,670 --> 00:35:16,079
interesting because these have been

948
00:35:20,390 --> 00:35:17,680
observed to fall

949
00:35:21,829 --> 00:35:20,400
and then have been stored in collections

950
00:35:23,589 --> 00:35:21,839
and have not been sitting around in the

951
00:35:25,670 --> 00:35:23,599
terrestrial environment getting altered

952
00:35:27,270 --> 00:35:25,680
and so

953
00:35:29,829 --> 00:35:27,280
the ones that we have the five that i

954
00:35:32,630 --> 00:35:29,839
mentioned they range in their fall dates

955
00:35:34,950 --> 00:35:32,640
from some sometime in the 1900s to the

956
00:35:39,910 --> 00:35:34,960
most recent one which is decent which

957
00:35:42,230 --> 00:35:39,920
fell in 2011 so again just about uh

958
00:35:43,670 --> 00:35:42,240
you know a decade ago or so

959
00:35:45,670 --> 00:35:43,680
and so

960
00:35:48,150 --> 00:35:45,680
the the next freshest one actually fell

961
00:35:49,910 --> 00:35:48,160
in 1960 so over half a century ago so

962
00:35:51,349 --> 00:35:49,920
this is clearly one of interest because

963
00:35:54,069 --> 00:35:51,359

if you're looking for

964
00:35:56,390 --> 00:35:54,079
uh organic compounds as well as other

965
00:35:58,230 --> 00:35:56,400
types of you know salts and other

966
00:35:59,750 --> 00:35:58,240
materials that

967
00:36:01,030 --> 00:35:59,760
otherwise could be altered pretty

968
00:36:02,550 --> 00:36:01,040
significantly in the terrestrial

969
00:36:04,550 --> 00:36:02,560
environment you want to be looking at

970
00:36:06,069 --> 00:36:04,560
something that's relatively fresh and so

971
00:36:07,589 --> 00:36:06,079
that's again something

972
00:36:09,910 --> 00:36:07,599
that is of great interest from the

973
00:36:11,750 --> 00:36:09,920
astrobiological perspective

974
00:36:13,910 --> 00:36:11,760
so

975
00:36:16,150 --> 00:36:13,920
i'm gonna as i mentioned uh give a

976
00:36:18,069 --> 00:36:16,160
little bit of um an example of each one

977
00:36:19,990 --> 00:36:18,079
of these uh to to give you a perspective

978
00:36:21,750 --> 00:36:20,000
on on how these are actually useful from

979
00:36:24,870 --> 00:36:21,760
that from that standpoint and what the

980
00:36:26,950 --> 00:36:24,880
limitations are as well so um on this

981
00:36:29,990 --> 00:36:26,960
slide i'm showing here on the left hand

982
00:36:31,829 --> 00:36:30,000
side uh some of the eating site veins

983
00:36:34,550 --> 00:36:31,839
and eating site is basically just this

984
00:36:36,550 --> 00:36:34,560
sort of mishmash or mixture of of these

985
00:36:39,270 --> 00:36:36,560
alteration products that are produced as

986
00:36:42,550 --> 00:36:39,280
a result of alteration of olivine

987
00:36:45,030 --> 00:36:42,560
and so it's things like clays as well as

988
00:36:47,589 --> 00:36:45,040

uh ferrohydrates and and and so it's got

989
00:36:49,190 --> 00:36:47,599
this sort of orangish stain stained

990
00:36:51,430 --> 00:36:49,200
color that you see on the left hand side

991
00:36:54,069 --> 00:36:51,440
upper left side here and so you can see

992
00:36:57,030 --> 00:36:54,079
eating site here in lafayette on the top

993
00:36:59,510 --> 00:36:57,040
on the left and you can see also some

994
00:37:02,310 --> 00:36:59,520
close-up of some of the eating site in

995
00:37:03,750 --> 00:37:02,320
nakhla and so on the right hand side on

996
00:37:04,430 --> 00:37:03,760
the other hand you've got carbonates in

997
00:37:16,870 --> 00:37:04,440
the

998
00:37:18,150 --> 00:37:16,880
in mccarroll 1996

999
00:37:19,670 --> 00:37:18,160
where they had

1000
00:37:21,109 --> 00:37:19,680
basically provided four lines of

1001
00:37:23,510 --> 00:37:21,119
evidence to suggest that there was

1002
00:37:26,710 --> 00:37:23,520
evidence of past biologic activity on

1003
00:37:28,710 --> 00:37:26,720
mars based on what they found in in the

1004
00:37:30,390 --> 00:37:28,720
in this particular meteorite including

1005
00:37:31,190 --> 00:37:30,400
the presence of these carbonates that

1006
00:37:32,150 --> 00:37:31,200
they

1007
00:37:33,589 --> 00:37:32,160
um

1008
00:37:35,670 --> 00:37:33,599
highlighted the fact that these were

1009
00:37:37,829 --> 00:37:35,680
deposited by water there was associated

1010
00:37:39,670 --> 00:37:37,839
organics there was also associated

1011
00:37:41,910 --> 00:37:39,680
magnetites that were

1012
00:37:43,829 --> 00:37:41,920
in association with some of the

1013
00:37:45,670 --> 00:37:43,839

other phases that were

1014
00:37:48,470 --> 00:37:45,680
the presence of both oxidized and

1015
00:37:50,069 --> 00:37:48,480
reduced phases which they suggested

1016
00:37:52,230 --> 00:37:50,079
indicated the presence of some sort of

1017
00:37:52,950 --> 00:37:52,240
biogenic activity in the past

1018
00:37:55,030 --> 00:37:52,960
so

1019
00:37:56,150 --> 00:37:55,040
that was that was of course a historic

1020
00:37:59,430 --> 00:37:56,160
study but i'm going to give you an

1021
00:38:00,630 --> 00:37:59,440
example now of a recent study by steel

1022
00:38:02,870 --> 00:38:00,640
at all which

1023
00:38:07,030 --> 00:38:02,880
just published this past february

1024
00:38:09,829 --> 00:38:07,040
and they applied co-located nanoscale

1025
00:38:13,190 --> 00:38:09,839
analyses of basically looking at the

1026
00:38:17,190 --> 00:38:13,200
textures as well as isotope compositions

1027
00:38:18,870 --> 00:38:17,200
tem studies as well as some of the

1028
00:38:20,950 --> 00:38:18,880
isotopic compositions that were measured

1029
00:38:24,550 --> 00:38:20,960
on these on the same samples

1030
00:38:26,630 --> 00:38:24,560
and what they saw was that there were

1031
00:38:29,589 --> 00:38:26,640
two different types of associations of

1032
00:38:30,870 --> 00:38:29,599
magnetite in this particular meteorite

1033
00:38:33,190 --> 00:38:30,880
and i'm showing the two different

1034
00:38:34,550 --> 00:38:33,200
examples one on the top one one on the

1035
00:38:35,750 --> 00:38:34,560
bottom on the left hand side of the

1036
00:38:38,470 --> 00:38:35,760
screen here

1037
00:38:39,430 --> 00:38:38,480
and you can see on the left here

1038
00:38:41,430 --> 00:38:39,440

that

1039
00:38:42,230 --> 00:38:41,440
some of the magnetites are associated

1040
00:38:44,950 --> 00:38:42,240
with

1041
00:38:46,670 --> 00:38:44,960
talc-like minerals so they are basically

1042
00:38:48,950 --> 00:38:46,680
suggesting some kind of

1043
00:38:50,710 --> 00:38:48,960
supernaturalization reaction

1044
00:38:52,150 --> 00:38:50,720
and on the bottom you see that some of

1045
00:38:54,790 --> 00:38:52,160
the carbonates

1046
00:38:56,470 --> 00:38:54,800
are basically associated the magnetites

1047
00:38:59,270 --> 00:38:56,480
associated with carbonates and

1048
00:39:01,910 --> 00:38:59,280
orthopyroxenes as well as some amorphous

1049
00:39:04,550 --> 00:39:01,920
orthopedic scenes as well and that is

1050
00:39:07,109 --> 00:39:04,560
basically indicative as these authors

1051
00:39:09,510 --> 00:39:07,119
suggest are carbonation reactions and

1052
00:39:12,150 --> 00:39:09,520
these are all associated with organics

1053
00:39:13,750 --> 00:39:12,160
and other associations that are devoid

1054
00:39:15,430 --> 00:39:13,760
of the magnetite are not are free of

1055
00:39:16,150 --> 00:39:15,440
basically free of organic materials and

1056
00:39:18,230 --> 00:39:16,160
so

1057
00:39:20,870 --> 00:39:18,240
what this study suggested was that in

1058
00:39:22,950 --> 00:39:20,880
fact abiotic synthesis was the important

1059
00:39:24,470 --> 00:39:22,960
process that was producing these

1060
00:39:26,950 --> 00:39:24,480
organics

1061
00:39:29,829 --> 00:39:26,960
as a result of aqueous hydrothermal

1062
00:39:32,470 --> 00:39:29,839
alteration on the surface of mars and so

1063
00:39:34,790 --> 00:39:32,480

they they basically are again

1064
00:39:36,230 --> 00:39:34,800
refuting the claims the original ones of

1065
00:39:37,990 --> 00:39:36,240
course by

1066
00:39:40,310 --> 00:39:38,000
mckay at all that these

1067
00:39:42,870 --> 00:39:40,320
these carbonates as well as the organics

1068
00:39:44,550 --> 00:39:42,880
were biogenic and so in fact

1069
00:39:46,390 --> 00:39:44,560
it's been suggested now by several

1070
00:39:50,870 --> 00:39:46,400
different studies that this is

1071
00:39:55,030 --> 00:39:50,880
this is likely to be inorganic synthesis

1072
00:39:57,670 --> 00:39:55,040
um the second example of nwa 7034

1073
00:40:00,390 --> 00:39:57,680
is basically this martian regolith

1074
00:40:02,310 --> 00:40:00,400
brecha and here is an example of a false

1075
00:40:03,589 --> 00:40:02,320
color backscattered electron image that

1076
00:40:05,109 --> 00:40:03,599
shows now

1077
00:40:07,349 --> 00:40:05,119
all of the different types of clasps

1078
00:40:08,630 --> 00:40:07,359
that make up this particular rock and

1079
00:40:10,710 --> 00:40:08,640
the interesting thing about this

1080
00:40:12,870 --> 00:40:10,720
material not not just the fact that it

1081
00:40:15,190 --> 00:40:12,880
has about one weight percent water but

1082
00:40:16,710 --> 00:40:15,200
also that among all of the martian

1083
00:40:19,190 --> 00:40:16,720
meteorites that we know about this is

1084
00:40:21,270 --> 00:40:19,200
the only one that has a bulk composition

1085
00:40:22,710 --> 00:40:21,280
that actually is similar

1086
00:40:26,710 --> 00:40:22,720
to the compositions that have been

1087
00:40:28,470 --> 00:40:26,720
measured from orbit which is this grs

1088
00:40:30,309 --> 00:40:28,480

indicated by

1089
00:40:31,910 --> 00:40:30,319
this yellow square which i'm not sure

1090
00:40:34,230 --> 00:40:31,920
that you can see very well but on the

1091
00:40:36,790 --> 00:40:34,240
plot on the right hand side

1092
00:40:39,109 --> 00:40:36,800
what's indicated as grs that's the

1093
00:40:41,829 --> 00:40:39,119
remote observation of the surface of

1094
00:40:44,710 --> 00:40:41,839
mars um the compositions and then the

1095
00:40:46,390 --> 00:40:44,720
red dots are all of the rover determined

1096
00:40:48,630 --> 00:40:46,400
compositions of the rocks that have been

1097
00:40:50,630 --> 00:40:48,640
determined i guess prior to 2013 by the

1098
00:40:53,190 --> 00:40:50,640
spirit and opportunity rovers

1099
00:40:54,710 --> 00:40:53,200
and so the the blue dot that you see

1100
00:40:57,510 --> 00:40:54,720
there that's a bulk composition of this

1101
00:40:59,030 --> 00:40:57,520
particular meteorite and it lands right

1102
00:41:00,470 --> 00:40:59,040
in the middle of the compositions that

1103
00:41:02,390 --> 00:41:00,480
are actually we're measuring on the

1104
00:41:04,230 --> 00:41:02,400
surface of mars and the martian

1105
00:41:06,470 --> 00:41:04,240
meteorites the ones that we know about

1106
00:41:07,829 --> 00:41:06,480
the snc meteorites are in this pink blob

1107
00:41:09,109 --> 00:41:07,839
right here which is quite different

1108
00:41:11,510 --> 00:41:09,119
actually and so

1109
00:41:13,510 --> 00:41:11,520
these meteorites by and large are not

1110
00:41:16,390 --> 00:41:13,520
representative of the crust of mars as

1111
00:41:19,190 --> 00:41:16,400
we know it but this particular rock 7034

1112
00:41:22,390 --> 00:41:19,200
seems to be an average composition

1113
00:41:24,710 --> 00:41:22,400

so a lot has been studied in this

1114
00:41:25,430 --> 00:41:24,720
particular rock in the last 10 years or

1115
00:41:27,990 --> 00:41:25,440
so

1116
00:41:29,990 --> 00:41:28,000
and in fact uh just there was a paper

1117
00:41:33,030 --> 00:41:30,000
that came out just in uh again in

1118
00:41:35,750 --> 00:41:33,040
february of 2022 which reviews all of

1119
00:41:37,910 --> 00:41:35,760
the information that's been acquired

1120
00:41:40,870 --> 00:41:37,920
i'm in my own laboratory we've actually

1121
00:41:43,270 --> 00:41:40,880
studied the water contents and and d to

1122
00:41:45,349 --> 00:41:43,280
h ratios and and various minerals in

1123
00:41:46,790 --> 00:41:45,359
these different class and there have

1124
00:41:48,069 --> 00:41:46,800
been a lot of other chronological

1125
00:41:49,829 --> 00:41:48,079
investigations that have been done as

1126
00:41:52,470 --> 00:41:49,839
well and based on all of these they've

1127
00:41:54,870 --> 00:41:52,480
compiled basically a history

1128
00:41:57,510 --> 00:41:54,880
of uh this particular regolith and its

1129
00:42:00,150 --> 00:41:57,520
martian habitability record and so this

1130
00:42:01,910 --> 00:42:00,160
is basically summarizing what we know

1131
00:42:04,150 --> 00:42:01,920
from just from looking at this one

1132
00:42:06,790 --> 00:42:04,160
meteorite about what we can understand

1133
00:42:08,470 --> 00:42:06,800
about uh the habitability of uh of the

1134
00:42:09,829 --> 00:42:08,480
region of mars where this particular

1135
00:42:10,550 --> 00:42:09,839
rock came from

1136
00:42:13,670 --> 00:42:10,560
so

1137
00:42:15,910 --> 00:42:13,680
basically the numbers correspond here to

1138
00:42:18,630 --> 00:42:15,920

the numbers on this timeline that's

1139
00:42:19,589 --> 00:42:18,640
shown on the bottom and so number one

1140
00:42:21,670 --> 00:42:19,599
which is

1141
00:42:23,270 --> 00:42:21,680
right around forty four fifty to forty

1142
00:42:24,630 --> 00:42:23,280
two hundred million years is when you

1143
00:42:27,829 --> 00:42:24,640
had a crustal building an early

1144
00:42:29,829 --> 00:42:27,839
volcanism uh happening on mars uh that's

1145
00:42:31,430 --> 00:42:29,839
recorded and some of the

1146
00:42:34,470 --> 00:42:31,440
ages the geochronology of some of the

1147
00:42:36,390 --> 00:42:34,480
zircons in this particular meteorite and

1148
00:42:38,630 --> 00:42:36,400
then there was sedimentological

1149
00:42:39,990 --> 00:42:38,640
processes and surface reworking that's

1150
00:42:42,870 --> 00:42:40,000
shown by this

1151
00:42:44,710 --> 00:42:42,880
dashed line here indicated by a two and

1152
00:42:46,390 --> 00:42:44,720
so this was a long time period over

1153
00:42:47,829 --> 00:42:46,400
which we don't really know exactly when

1154
00:42:49,270 --> 00:42:47,839
this happened but there was probably a

1155
00:42:50,630 --> 00:42:49,280
lot of impacts that were happening on

1156
00:42:52,069 --> 00:42:50,640
mars at the time

1157
00:42:54,069 --> 00:42:52,079
and so

1158
00:42:56,309 --> 00:42:54,079
somewhere in between the sort of igneous

1159
00:42:58,550 --> 00:42:56,319
formation of this rock as well as the

1160
00:43:00,550 --> 00:42:58,560
start of the these sedimentological

1161
00:43:02,630 --> 00:43:00,560
processes there might have been a period

1162
00:43:04,550 --> 00:43:02,640
of planetary habitability somewhere

1163
00:43:06,150 --> 00:43:04,560

early on in the nowakian

1164
00:43:08,230 --> 00:43:06,160
and subsequent to that there was a

1165
00:43:11,109 --> 00:43:08,240
lithification a huge impact sometime

1166
00:43:13,510 --> 00:43:11,119
around 1500 million years ago

1167
00:43:15,990 --> 00:43:13,520
and that's shown here as number three

1168
00:43:17,990 --> 00:43:16,000
and then after that there was some post

1169
00:43:18,790 --> 00:43:18,000
impact hydrothermal alteration that's

1170
00:43:21,990 --> 00:43:18,800
shown

1171
00:43:22,710 --> 00:43:22,000
by four and five and then eventually

1172
00:43:27,430 --> 00:43:22,720
it's

1173
00:43:28,870 --> 00:43:27,440
surface of mars only about five to 15

1174
00:43:30,069 --> 00:43:28,880
million years ago

1175
00:43:32,150 --> 00:43:30,079
and then of course terrestrial

1176
00:43:34,790 --> 00:43:32,160
alteration here on the surface of of the

1177
00:43:37,109 --> 00:43:34,800
earth and so that's basically

1178
00:43:39,510 --> 00:43:37,119
the history from from studying this

1179
00:43:42,630 --> 00:43:39,520
particular meteorite

1180
00:43:44,470 --> 00:43:42,640
now decent this is the last one

1181
00:43:46,069 --> 00:43:44,480
example that i'm going to give you

1182
00:43:48,630 --> 00:43:46,079
this is the one that's the freshest

1183
00:43:50,390 --> 00:43:48,640
martian meteorite fall and here are some

1184
00:43:52,230 --> 00:43:50,400
images of this fresh rock you can see

1185
00:43:53,109 --> 00:43:52,240
the beautiful fusion crust that's not at

1186
00:43:55,190 --> 00:43:53,119
all

1187
00:43:57,109 --> 00:43:55,200
altered and the back scattered electron

1188
00:43:59,990 --> 00:43:57,119

image on the left side here lower left

1189
00:44:01,910 --> 00:44:00,000
shows the texture which is all it has

1190
00:44:04,470 --> 00:44:01,920
some olivine phenocrysts and a ground

1191
00:44:05,910 --> 00:44:04,480
mass of pyroxene and plagioclase

1192
00:44:07,910 --> 00:44:05,920
and

1193
00:44:12,069 --> 00:44:07,920
this particular rock so there's a recent

1194
00:44:14,390 --> 00:44:12,079
study by uh jeremy at all 2019 where

1195
00:44:16,870 --> 00:44:14,400
they analyzed organics as well as some

1196
00:44:19,190 --> 00:44:16,880
soluble salts from this particular

1197
00:44:21,030 --> 00:44:19,200
meteorite and on the left-hand side

1198
00:44:22,870 --> 00:44:21,040
actually it shows sort of a comparison

1199
00:44:26,550 --> 00:44:22,880
so they analyzed the meteorite as well

1200
00:44:28,790 --> 00:44:26,560
as some of the local soil some wetter as

1201
00:44:30,710 --> 00:44:28,800
well as some drier soils from the strewn

1202
00:44:32,870 --> 00:44:30,720
field the area where this meteorite was

1203
00:44:34,069 --> 00:44:32,880
formed and so they compared the two and

1204
00:44:35,750 --> 00:44:34,079
they found that there were actually

1205
00:44:37,030 --> 00:44:35,760
quite significant differences between

1206
00:44:38,790 --> 00:44:37,040
what they found in the meteorite and

1207
00:44:40,309 --> 00:44:38,800
what they found in the soils where this

1208
00:44:41,829 --> 00:44:40,319
meteorite came from

1209
00:44:43,430 --> 00:44:41,839
and they also looked at the soluble

1210
00:44:45,430 --> 00:44:43,440
salts in these things and that they

1211
00:44:48,150 --> 00:44:45,440
found differences also

1212
00:44:51,829 --> 00:44:48,160
as well and so what they basically

1213
00:44:53,910 --> 00:44:51,839

suggested based on this was that

1214
00:44:55,670 --> 00:44:53,920
this particular meteorite was not

1215
00:44:57,589 --> 00:44:55,680
contaminated significantly in the

1216
00:45:00,309 --> 00:44:57,599
terrestrial environment and that the

1217
00:45:02,550 --> 00:45:00,319
soluble salts were likely deposited by

1218
00:45:04,790 --> 00:45:02,560
martian brine similar to terrestrial

1219
00:45:06,069 --> 00:45:04,800
seawater

1220
00:45:08,470 --> 00:45:06,079
we actually

1221
00:45:10,069 --> 00:45:08,480
in my group we had studied the age of

1222
00:45:12,550 --> 00:45:10,079
this particular rock we had determined

1223
00:45:15,270 --> 00:45:12,560
that this was about 600 million years

1224
00:45:17,670 --> 00:45:15,280
old based on sumerian neodymium rubidium

1225
00:45:19,430 --> 00:45:17,680
strontium dating of this rock and so

1226
00:45:21,430 --> 00:45:19,440
what this suggests in combination with

1227
00:45:24,950 --> 00:45:21,440
the work that these uh that jerramillo

1228
00:45:26,710 --> 00:45:24,960
at all did is that in fact this um uh

1229
00:45:28,790 --> 00:45:26,720
crustal fluid interaction happened

1230
00:45:31,030 --> 00:45:28,800
somewhere less than 600 million years

1231
00:45:32,870 --> 00:45:31,040
ago on mars and so this implies the

1232
00:45:34,870 --> 00:45:32,880
presence of temporary but potentially

1233
00:45:36,630 --> 00:45:34,880
habitable brines sometime during the

1234
00:45:38,630 --> 00:45:36,640
amazonian

1235
00:45:40,950 --> 00:45:38,640
the problem though is that

1236
00:45:43,510 --> 00:45:40,960
in fact you know we actually did this

1237
00:45:46,150 --> 00:45:43,520
experiment on this particular rock to

1238
00:45:47,190 --> 00:45:46,160

see how fast terrestrial alteration can

1239
00:45:48,950 --> 00:45:47,200
actually

1240
00:45:50,390 --> 00:45:48,960
mess up things and so we took three

1241
00:45:52,390 --> 00:45:50,400
pieces of tissue

1242
00:45:54,309 --> 00:45:52,400
and we

1243
00:45:56,470 --> 00:45:54,319
basically put them out in the desert and

1244
00:45:58,390 --> 00:45:56,480
we analyzed one right away and then we

1245
00:46:01,190 --> 00:45:58,400
analyzed one a year later and another

1246
00:46:03,510 --> 00:46:01,200
one three years later and so

1247
00:46:05,910 --> 00:46:03,520
uh we measured the water abundances and

1248
00:46:07,430 --> 00:46:05,920
d2h ratios and

1249
00:46:10,390 --> 00:46:07,440
basically this is what we found we

1250
00:46:11,990 --> 00:46:10,400
measured basically a mineral that is

1251
00:46:14,630 --> 00:46:12,000
naturally has very low abundances of

1252
00:46:18,069 --> 00:46:14,640
water and so what we found

1253
00:46:19,829 --> 00:46:18,079
is that the fresh decent i'm sorry the

1254
00:46:21,270 --> 00:46:19,839
fresh decent which is shown here in the

1255
00:46:23,190 --> 00:46:21,280
black dots

1256
00:46:25,510 --> 00:46:23,200
this is where it falls

1257
00:46:27,750 --> 00:46:25,520
and this is after no exposure to the

1258
00:46:30,069 --> 00:46:27,760
earth in the terrestrial environment but

1259
00:46:32,790 --> 00:46:30,079
as soon as you put put it out in the

1260
00:46:35,349 --> 00:46:32,800
environment within a year it gets

1261
00:46:37,109 --> 00:46:35,359
altered very significantly and you see

1262
00:46:38,870 --> 00:46:37,119
all this distribution of data where you

1263
00:46:41,270 --> 00:46:38,880

have higher water abundances and lower

1264
00:46:44,230 --> 00:46:41,280
delta d values and so the fresh season

1265
00:46:46,309 --> 00:46:44,240
actually has high d2h ratios whereas the

1266
00:46:49,270 --> 00:46:46,319
altered ones don't and so

1267
00:46:52,150 --> 00:46:49,280
significant alteration happens very very

1268
00:46:54,230 --> 00:46:52,160
quickly and so you you know meteorites

1269
00:46:56,230 --> 00:46:54,240
are prone to that and so we have you

1270
00:46:57,589 --> 00:46:56,240
know it's not just the alteration that

1271
00:46:59,510 --> 00:46:57,599
that makes a difference it's also the

1272
00:47:01,430 --> 00:46:59,520
fact that we don't have the geologic

1273
00:47:03,670 --> 00:47:01,440
context from where they came from and

1274
00:47:06,550 --> 00:47:03,680
then the process of actually delivering

1275
00:47:08,630 --> 00:47:06,560
these samples screws them up even more

1276
00:47:10,950 --> 00:47:08,640
because you had the impact process of

1277
00:47:13,030 --> 00:47:10,960
course shocks these rocks and so

1278
00:47:15,270 --> 00:47:13,040
sometimes some of the signatures that we

1279
00:47:16,950 --> 00:47:15,280
see we can't be entirely sure whether

1280
00:47:19,910 --> 00:47:16,960
they're a result of shock or if the

1281
00:47:21,109 --> 00:47:19,920
result of terrestrial alteration and so

1282
00:47:23,589 --> 00:47:21,119
rigorous assessment of the

1283
00:47:25,910 --> 00:47:23,599
astrobiological potential of mars really

1284
00:47:27,990 --> 00:47:25,920
requires sample return

1285
00:47:30,950 --> 00:47:28,000
and so katie just talked about the fact

1286
00:47:33,109 --> 00:47:30,960
that mars 2020 is already on its way to

1287
00:47:35,349 --> 00:47:33,119
collecting rocks and here is just a

1288
00:47:37,589 --> 00:47:35,359

little summary

1289
00:47:40,150 --> 00:47:37,599
showing all of the different rocks that

1290
00:47:42,150 --> 00:47:40,160
have been collected so far

1291
00:47:44,950 --> 00:47:42,160
what you're seeing here are the abraded

1292
00:47:46,790 --> 00:47:44,960
patches as well as the cores the two

1293
00:47:49,190 --> 00:47:46,800
rook they've basically been taking

1294
00:47:50,549 --> 00:47:49,200
paired samples from each rock type that

1295
00:47:52,630 --> 00:47:50,559
they've collected and so there's four

1296
00:47:53,430 --> 00:47:52,640
localities that have been collected so

1297
00:47:55,750 --> 00:47:53,440
far

1298
00:47:57,670 --> 00:47:55,760
and these represent basalts as well as

1299
00:47:59,270 --> 00:47:57,680
some of these olivine carbonate rocks

1300
00:48:01,430 --> 00:47:59,280
that katie talked about so we've got

1301
00:48:03,270 --> 00:48:01,440
four pairs of rocks one atmosphere

1302
00:48:04,790 --> 00:48:03,280
sample and one witness tube at the

1303
00:48:06,710 --> 00:48:04,800
current time

1304
00:48:08,950 --> 00:48:06,720
so basically

1305
00:48:12,309 --> 00:48:08,960
the

1306
00:48:14,790 --> 00:48:12,319
samples that we have already got as part

1307
00:48:15,589 --> 00:48:14,800
of the cache that's on march 2020 right

1308
00:48:17,670 --> 00:48:15,599
now

1309
00:48:18,630 --> 00:48:17,680
as well as those that that katie

1310
00:48:20,630 --> 00:48:18,640
mentioned that we're going to be

1311
00:48:22,950 --> 00:48:20,640
sampling the delta region

1312
00:48:25,750 --> 00:48:22,960
in jezreel crater pretty soon

1313
00:48:27,829 --> 00:48:25,760

all of those samples together

1314
00:48:29,510 --> 00:48:27,839
we believe will address each of the high

1315
00:48:31,510 --> 00:48:29,520
priority science goals that were

1316
00:48:35,109 --> 00:48:31,520
identified by the community and this was

1317
00:48:36,390 --> 00:48:35,119
published recently in 2019 in the imost

1318
00:48:39,349 --> 00:48:36,400
report

1319
00:48:41,910 --> 00:48:39,359
and they identified basically seven

1320
00:48:43,990 --> 00:48:41,920
high level goals of which uh the

1321
00:48:45,990 --> 00:48:44,000
geological environment and life goals

1322
00:48:49,349 --> 00:48:46,000
are actually sort of i've highlighted a

1323
00:48:51,190 --> 00:48:49,359
few of those to show that those ones are

1324
00:48:52,950 --> 00:48:51,200
going to be particularly important to

1325
00:48:54,549 --> 00:48:52,960
determine the geologic context of the

1326
00:48:57,270 --> 00:48:54,559
samples and then of course the

1327
00:48:59,109 --> 00:48:57,280
biosignatures

1328
00:49:00,790 --> 00:48:59,119
in particular the focus is going to be

1329
00:49:03,109 --> 00:49:00,800
of course on ancient biosignatures

1330
00:49:05,510 --> 00:49:03,119
that's very low likelihood of modern

1331
00:49:07,510 --> 00:49:05,520
bias signatures but still we will be

1332
00:49:09,190 --> 00:49:07,520
have the means to actually make those

1333
00:49:11,430 --> 00:49:09,200
assessments and to study these well

1334
00:49:13,829 --> 00:49:11,440
characterized to determine that

1335
00:49:16,630 --> 00:49:13,839
so all of these

1336
00:49:20,069 --> 00:49:16,640
samples will actually be able to address

1337
00:49:21,190 --> 00:49:20,079
all of these high priority goals

1338
00:49:24,870 --> 00:49:21,200

from

1339
00:49:27,829 --> 00:49:24,880
so

1340
00:49:29,589 --> 00:49:27,839
this is actually just then a notional

1341
00:49:31,750 --> 00:49:29,599
architecture at the current time this is

1342
00:49:34,230 --> 00:49:31,760
still in work we are currently in phase

1343
00:49:35,589 --> 00:49:34,240
a for the mars sample return program

1344
00:49:37,589 --> 00:49:35,599
and so

1345
00:49:40,390 --> 00:49:37,599
mars 2020

1346
00:49:41,990 --> 00:49:40,400
is actually part of the initial it's the

1347
00:49:43,990 --> 00:49:42,000
initial phase of the mars sample return

1348
00:49:47,030 --> 00:49:44,000
campaign and the mars sample return

1349
00:49:48,710 --> 00:49:47,040
program is the next phase which will

1350
00:49:51,349 --> 00:49:48,720
basically comprise of a couple of

1351
00:49:54,150 --> 00:49:51,359
missions the earth return orbiter and

1352
00:49:56,150 --> 00:49:54,160
the sample retrieval lander and so both

1353
00:49:58,589 --> 00:49:56,160
of those are actually going to be

1354
00:50:00,870 --> 00:49:58,599
launched sometime we believe in the

1355
00:50:03,349 --> 00:50:00,880
2027-2028 time frame

1356
00:50:05,430 --> 00:50:03,359
and then we hope to bring these samples

1357
00:50:08,390 --> 00:50:05,440
back by 2033.

1358
00:50:09,829 --> 00:50:08,400
so uh these are then just the different

1359
00:50:12,309 --> 00:50:09,839
aspects of the mars sample return

1360
00:50:13,750 --> 00:50:12,319
program and

1361
00:50:15,829 --> 00:50:13,760
the sample science integrity

1362
00:50:17,910 --> 00:50:15,839
considerations that we that are clearly

1363
00:50:19,750 --> 00:50:17,920

going to be very important for

1364
00:50:22,069 --> 00:50:19,760
thinking about uh

1365
00:50:23,190 --> 00:50:22,079
these materials as we bring them back in

1366
00:50:24,870 --> 00:50:23,200
particular

1367
00:50:26,790 --> 00:50:24,880
the things that we are most concerned

1368
00:50:28,470 --> 00:50:26,800
about are contamination limits and

1369
00:50:30,470 --> 00:50:28,480
contamination knowledge we want to make

1370
00:50:32,710 --> 00:50:30,480
sure the mechanical integrity of the

1371
00:50:35,349 --> 00:50:32,720
samples as well as the tubes which is

1372
00:50:37,990 --> 00:50:35,359
the return sample tube assemblies is is

1373
00:50:40,069 --> 00:50:38,000
maintained the magnetic field limits are

1374
00:50:41,670 --> 00:50:40,079
are also of concern as well as the

1375
00:50:43,270 --> 00:50:41,680
temperature histories and so we're

1376
00:50:45,190 --> 00:50:43,280
making sure that all of these things are

1377
00:50:46,470 --> 00:50:45,200
taken into consideration

1378
00:50:48,549 --> 00:50:46,480
um

1379
00:50:50,950 --> 00:50:48,559
the current status basically is that we

1380
00:50:52,710 --> 00:50:50,960
have we are in phase a i'm not going to

1381
00:50:54,950 --> 00:50:52,720
go into all of the details here but

1382
00:50:56,549 --> 00:50:54,960
basically we're currently ensuring

1383
00:50:58,069 --> 00:50:56,559
alignment with class a mission

1384
00:50:59,510 --> 00:50:58,079
requirements meaning that this is a high

1385
00:51:02,630 --> 00:50:59,520
priority mission

1386
00:51:04,950 --> 00:51:02,640
and the mission timeline and

1387
00:51:07,270 --> 00:51:04,960
basically the architecture are still in

1388
00:51:09,829 --> 00:51:07,280

the process of being

1389
00:51:12,069 --> 00:51:09,839
confirmed at this point so

1390
00:51:14,069 --> 00:51:12,079
i'm going to be happy to take any

1391
00:51:16,950 --> 00:51:14,079
questions at this point i know i'm a

1392
00:51:18,870 --> 00:51:16,960
couple of minutes over my time so

1393
00:51:27,030 --> 00:51:18,880
if you have any questions i'm happy to

1394
00:51:32,069 --> 00:51:30,309
so so minnie and i will uh will sit down

1395
00:51:33,589 --> 00:51:32,079
um in these

1396
00:51:37,670 --> 00:51:33,599
stairs over here

1397
00:51:40,390 --> 00:51:37,680
uh katie will also join us

1398
00:51:42,150 --> 00:51:40,400
and please please please head over to

1399
00:51:43,589 --> 00:51:42,160
the microphone

1400
00:51:51,910 --> 00:51:43,599
with your

1401
00:51:55,910 --> 00:51:53,510
okay he's back here can we hear you

1402
00:51:55,920 --> 00:52:01,589
yes i'm here great

1403
00:52:06,630 --> 00:52:05,270
um so so i'll uh

1404
00:52:09,270 --> 00:52:06,640
i'll go ahead and start and then and

1405
00:52:10,790 --> 00:52:09,280
then maybe take some some from on

1406
00:52:13,109 --> 00:52:10,800
online also

1407
00:52:14,870 --> 00:52:13,119
um so i i would like to hear i guess

1408
00:52:17,589 --> 00:52:14,880
from both of you just from your own

1409
00:52:20,710 --> 00:52:17,599
personal you know curiosity what

1410
00:52:23,430 --> 00:52:20,720
what you are most you know really really

1411
00:52:25,349 --> 00:52:23,440
interested uh looking for as as you know

1412
00:52:26,470 --> 00:52:25,359
data is coming in or what do you you

1413
00:52:28,950 --> 00:52:26,480

know what do you really want to know

1414
00:52:31,349 --> 00:52:28,960
that you think you know that

1415
00:52:34,549 --> 00:52:31,359
the next data might be able to tell you

1416
00:52:38,950 --> 00:52:37,030
yeah um i mean i think that of course

1417
00:52:39,829 --> 00:52:38,960
the the first question we're all asking

1418
00:52:42,069 --> 00:52:39,839
is

1419
00:52:43,670 --> 00:52:42,079
were there signs of ancient life on mars

1420
00:52:45,430 --> 00:52:43,680
every single mission that has gone to

1421
00:52:47,589 --> 00:52:45,440
mars has discovered habitable

1422
00:52:49,589 --> 00:52:47,599
environments so we've we've pretty much

1423
00:52:51,430 --> 00:52:49,599
answered that question mars was a

1424
00:52:53,109 --> 00:52:51,440
habitable planet and so then the

1425
00:52:55,349 --> 00:52:53,119
question is you know can we take that

1426
00:52:58,150 --> 00:52:55,359
next step in understanding whether life

1427
00:53:00,710 --> 00:52:58,160
actually existed on mars and so you know

1428
00:53:02,630 --> 00:53:00,720
the the opportunity to use the mars 2020

1429
00:53:05,349 --> 00:53:02,640
data in situ on the surface of mars to

1430
00:53:07,270 --> 00:53:05,359
identify possible biosignatures is is so

1431
00:53:09,430 --> 00:53:07,280
exciting to me and and the thought that

1432
00:53:11,829 --> 00:53:09,440
that then feeds into what could be a

1433
00:53:13,030 --> 00:53:11,839
total paradigm shift in terms of how we

1434
00:53:14,790 --> 00:53:13,040
think about

1435
00:53:16,950 --> 00:53:14,800
life in the solar system life in the

1436
00:53:18,790 --> 00:53:16,960
universe you know it's incredibly

1437
00:53:20,390 --> 00:53:18,800
exciting to be a part of an effort like

1438
00:53:22,390 --> 00:53:20,400

that and then knowing that the work that

1439
00:53:26,069 --> 00:53:22,400
we're doing the day-to-day grind that we

1440
00:53:28,390 --> 00:53:26,079
do on rover mission ops is enabling such

1441
00:53:29,990 --> 00:53:28,400
great science for decades to come and so

1442
00:53:31,910 --> 00:53:30,000
you know it's such an honor and i feel

1443
00:53:33,270 --> 00:53:31,920
so lucky to be a part of that effort and

1444
00:53:36,150 --> 00:53:33,280
that's really what i think keeps me

1445
00:53:40,230 --> 00:53:38,069
thank you katie uh will you have any

1446
00:53:42,549 --> 00:53:40,240
thoughts you'd like to share minnie

1447
00:53:43,670 --> 00:53:42,559
well you know i i mentioned the fact

1448
00:53:46,150 --> 00:53:43,680
that uh

1449
00:53:48,710 --> 00:53:46,160
i started out as a graduate student

1450
00:53:51,510 --> 00:53:48,720
studying martian meteorites and and at

1451
00:53:53,270 --> 00:53:51,520
that point and i won't say exactly how

1452
00:53:55,589 --> 00:53:53,280
long ago that was but

1453
00:53:57,750 --> 00:53:55,599
it was always more sample return was 10

1454
00:53:59,750 --> 00:53:57,760
years down the road always 10 years down

1455
00:54:01,990 --> 00:53:59,760
the road always 10 years down the road

1456
00:54:03,829 --> 00:54:02,000
and now this is finally

1457
00:54:06,470 --> 00:54:03,839
this is the first time that it actually

1458
00:54:08,470 --> 00:54:06,480
feels like it is it is on its way we're

1459
00:54:11,109 --> 00:54:08,480
already collecting those rocks we're

1460
00:54:13,829 --> 00:54:11,119
catching those rocks we have we're in

1461
00:54:16,790 --> 00:54:13,839
phase a there's actual funding to

1462
00:54:18,230 --> 00:54:16,800
support the work and it's super exciting

1463
00:54:20,069 --> 00:54:18,240

to me to think that we'll actually bring

1464
00:54:21,910 --> 00:54:20,079
these samples back and and we'll be

1465
00:54:23,670 --> 00:54:21,920
studying them for decades to come you

1466
00:54:25,829 --> 00:54:23,680
know the lunar samples that we brought

1467
00:54:28,230 --> 00:54:25,839
back from the moon you know they they

1468
00:54:30,150 --> 00:54:28,240
opened those some some tubes that have

1469
00:54:31,430 --> 00:54:30,160
been sealed for 50 years they opened

1470
00:54:33,190 --> 00:54:31,440
them last year

1471
00:54:34,630 --> 00:54:33,200
and so you know this is this is going to

1472
00:54:35,510 --> 00:54:34,640
be a treasure trove that we're going to

1473
00:54:38,069 --> 00:54:35,520
be

1474
00:54:39,829 --> 00:54:38,079
utilizing for decades to come and so

1475
00:54:41,829 --> 00:54:39,839
yeah i can't wait

1476
00:54:44,309 --> 00:54:41,839
thank you let's uh let's take a question

1477
00:54:45,750 --> 00:54:44,319
from the microphone go ahead

1478
00:54:48,069 --> 00:54:45,760
thanks very much for a great set of

1479
00:54:49,190 --> 00:54:48,079
talks uh you mentioned that for some of

1480
00:54:50,950 --> 00:54:49,200
these meteorites they have different

1481
00:54:52,549 --> 00:54:50,960
ages and if you heat them up they

1482
00:54:54,470 --> 00:54:52,559
release gases that are represented of

1483
00:54:55,829 --> 00:54:54,480
the martian atmosphere can you use that

1484
00:54:58,710 --> 00:54:55,839
to somehow track the evolution of the

1485
00:55:00,870 --> 00:54:58,720
martian atmosphere over time

1486
00:55:02,789 --> 00:55:00,880
yeah so that's a great question so you

1487
00:55:04,630 --> 00:55:02,799
know the

1488
00:55:07,510 --> 00:55:04,640

the meteorites that have been studied in

1489
00:55:09,510 --> 00:55:07,520
that mode there's there's two of them

1490
00:55:12,069 --> 00:55:09,520
actually for which that analysis has

1491
00:55:15,349 --> 00:55:12,079
been done and they're both sugartites

1492
00:55:16,950 --> 00:55:15,359
and they're both about 150 to 160

1493
00:55:18,789 --> 00:55:16,960
million years old

1494
00:55:20,789 --> 00:55:18,799
but that's not the atmosphere that

1495
00:55:23,109 --> 00:55:20,799
you're sampling which is sampling is the

1496
00:55:25,030 --> 00:55:23,119
atmosphere at the time of the ejection

1497
00:55:27,510 --> 00:55:25,040
event the impact

1498
00:55:30,309 --> 00:55:27,520
that caused some of the melting impact

1499
00:55:32,789 --> 00:55:30,319
melting in the rock that ejected it and

1500
00:55:35,270 --> 00:55:32,799
that happened less than 20 million years

1501
00:55:36,710 --> 00:55:35,280
ago for all of the martian meteorites

1502
00:55:38,390 --> 00:55:36,720
for the ones that were actually measured

1503
00:55:41,670 --> 00:55:38,400
at all you know that happened about

1504
00:55:42,870 --> 00:55:41,680
maybe two to three million years ago and

1505
00:55:45,349 --> 00:55:42,880
there's not a whole lot that's happened

1506
00:55:48,390 --> 00:55:45,359
to the martian atmosphere and over that

1507
00:55:49,829 --> 00:55:48,400
you know short span of time so um

1508
00:55:52,230 --> 00:55:49,839
i wish there were actually you know ways

1509
00:55:54,950 --> 00:55:52,240
to actually look at sort of uh samples

1510
00:55:57,670 --> 00:55:54,960
that maybe have had longer

1511
00:55:59,030 --> 00:55:57,680
ejection ages but we don't really have

1512
00:56:02,069 --> 00:55:59,040
um you know

1513
00:56:04,950 --> 00:56:02,079

we don't have a huge spread in that in

1514
00:56:07,430 --> 00:56:04,960
that time thank you i'll add one thing

1515
00:56:09,430 --> 00:56:07,440
i'll add actually to that answer is that

1516
00:56:12,150 --> 00:56:09,440
that's what makes it so exciting for us

1517
00:56:14,230 --> 00:56:12,160
to identify things like carbonate in the

1518
00:56:16,309 --> 00:56:14,240
samples that we are collecting with

1519
00:56:19,349 --> 00:56:16,319
perseverance because the potential to

1520
00:56:21,430 --> 00:56:19,359
have carbonate forming in a surface near

1521
00:56:23,670 --> 00:56:21,440
subsurface environment is what gives us

1522
00:56:25,430 --> 00:56:23,680
the potential to actually record the

1523
00:56:27,430 --> 00:56:25,440
martian environment at the time that

1524
00:56:29,190 --> 00:56:27,440
that carbonate formed in the very

1525
00:56:31,270 --> 00:56:29,200
distant past and so the potential to

1526
00:56:33,910 --> 00:56:31,280
bring those for example the carbonate

1527
00:56:36,150 --> 00:56:33,920
very rocks back to earth and have the

1528
00:56:38,710 --> 00:56:36,160
ability to study ancient climate using

1529
00:56:40,549 --> 00:56:38,720
some of the very conventional isotopic

1530
00:56:42,630 --> 00:56:40,559
techniques that we use to understand

1531
00:56:44,309 --> 00:56:42,640
past environment and atmosphere here on

1532
00:56:46,470 --> 00:56:44,319
earth we have that potential with

1533
00:56:48,470 --> 00:56:46,480
minerals like carbonate in the martian

1534
00:56:50,230 --> 00:56:48,480
samples that perseverance is collecting

1535
00:56:52,069 --> 00:56:50,240
exactly now i think that that's such a

1536
00:56:54,150 --> 00:56:52,079
great point you know the

1537
00:56:55,910 --> 00:56:54,160
the meteorites are i just mentioned

1538
00:56:57,829 --> 00:56:55,920

there are limitations to these things

1539
00:57:00,150 --> 00:56:57,839
and absolutely we need to get these

1540
00:57:01,670 --> 00:57:00,160
samples back to really be able to do the

1541
00:57:03,190 --> 00:57:01,680
kinds of cool things that katie just

1542
00:57:05,190 --> 00:57:03,200
mentioned

1543
00:57:06,950 --> 00:57:05,200
okay let's take next question

1544
00:57:09,349 --> 00:57:06,960
university of florida

1545
00:57:10,710 --> 00:57:09,359
um i was quite wondering about the snc

1546
00:57:13,030 --> 00:57:10,720
meteorites if you're learning anything

1547
00:57:16,230 --> 00:57:13,040
about the passage

1548
00:57:17,829 --> 00:57:16,240
the timeline with some of these newer

1549
00:57:19,109 --> 00:57:17,839
snc meteorites if you're learning

1550
00:57:21,589 --> 00:57:19,119
anything more about the radiation

1551
00:57:22,390 --> 00:57:21,599
exposure how that's affecting and

1552
00:57:24,309 --> 00:57:22,400
just

1553
00:57:27,030 --> 00:57:24,319
overall how long is it taking to get

1554
00:57:29,510 --> 00:57:27,040
from mars to earth yeah so you know

1555
00:57:32,549 --> 00:57:29,520
absolutely i think

1556
00:57:34,710 --> 00:57:32,559
uh it's been shown by modeling efforts

1557
00:57:37,030 --> 00:57:34,720
that really the transit time from mars

1558
00:57:39,430 --> 00:57:37,040
to earth is relatively short its own

1559
00:57:41,190 --> 00:57:39,440
order 10 to 20 million years and that's

1560
00:57:43,829 --> 00:57:41,200
what we're seeing for most of these

1561
00:57:46,150 --> 00:57:43,839
martian meteorites actually

1562
00:57:48,549 --> 00:57:46,160
the exposure ages for these martian

1563
00:57:52,470 --> 00:57:48,559

meteorites is at most about 20 20

1564
00:57:55,670 --> 00:57:54,390
i'm sure there have been you know

1565
00:57:57,109 --> 00:57:55,680
martial meteorites have been coming to

1566
00:57:59,430 --> 00:57:57,119
us throughout the geologic history of

1567
00:58:00,710 --> 00:57:59,440
the earth but you know they they clearly

1568
00:58:02,150 --> 00:58:00,720
you know we're only seeing the most

1569
00:58:04,630 --> 00:58:02,160
recent ones because they won't they're

1570
00:58:06,710 --> 00:58:04,640
the only ones that have survived right

1571
00:58:07,910 --> 00:58:06,720
so what we're learning though is that at

1572
00:58:09,030 --> 00:58:07,920
least the ones that we have in our

1573
00:58:10,630 --> 00:58:09,040
collections

1574
00:58:12,549 --> 00:58:10,640
they're all less than 20 million years

1575
00:58:14,549 --> 00:58:12,559
and it's consistent with theoretical

1576
00:58:17,750 --> 00:58:14,559
modeling of that

1577
00:58:22,470 --> 00:58:21,109
you have any questions online we do

1578
00:58:25,270 --> 00:58:22,480
question for many

1579
00:58:28,069 --> 00:58:25,280
uh given that terrestrial alteration

1580
00:58:30,789 --> 00:58:28,079
happens so rapidly could this have also

1581
00:58:32,549 --> 00:58:30,799
affected the high bulk water content in

1582
00:58:34,829 --> 00:58:32,559
the regolith breccia

1583
00:58:37,910 --> 00:58:34,839
nwa

1584
00:58:41,030 --> 00:58:37,920
7034 yeah so that's you know that's a

1585
00:58:43,030 --> 00:58:41,040
good question um

1586
00:58:45,430 --> 00:58:43,040
it's uh

1587
00:58:48,390 --> 00:58:45,440
it's had a terrestrial residence time i

1588
00:58:49,430 --> 00:58:48,400

believe a few tens of thousands of years

1589
00:58:51,270 --> 00:58:49,440
but

1590
00:58:53,670 --> 00:58:51,280
the amount of water that it would take

1591
00:58:56,069 --> 00:58:53,680
to actually alter it to that great the

1592
00:58:57,990 --> 00:58:56,079
great extent would would be a lot right

1593
00:58:59,750 --> 00:58:58,000
i mean if if you started out with

1594
00:59:01,190 --> 00:58:59,760
something like a few hundred parts per

1595
00:59:03,589 --> 00:59:01,200
million which is typical of the other

1596
00:59:05,589 --> 00:59:03,599
martian meteorites to get it up to a

1597
00:59:07,670 --> 00:59:05,599
weight percent would mean a significant

1598
00:59:10,549 --> 00:59:07,680
amount of contamination in which case

1599
00:59:11,349 --> 00:59:10,559
you would not see the uh you know d2h

1600
00:59:14,549 --> 00:59:11,359
the

1601
00:59:17,190 --> 00:59:14,559
sample

1602
00:59:19,430 --> 00:59:17,200
uh we see a range in them right i mean

1603
00:59:22,710 --> 00:59:19,440
we see relatively high values up to

1604
00:59:25,750 --> 00:59:22,720
maybe plus you know 1500 to 2000

1605
00:59:27,589 --> 00:59:25,760
um down to near terrestrial values if

1606
00:59:29,109 --> 00:59:27,599
you if all of that water had been

1607
00:59:32,950 --> 00:59:29,119
terrestrial

1608
00:59:35,030 --> 00:59:32,960
h ratios so

1609
00:59:36,309 --> 00:59:35,040
um i think there's been some alteration

1610
00:59:38,710 --> 00:59:36,319
but

1611
00:59:41,109 --> 00:59:38,720
not not everything has you know not all

1612
00:59:44,870 --> 00:59:41,119
that water could be could be

1613
00:59:49,750 --> 00:59:46,630

i think i think it's time for us to

1614
00:59:52,230 --> 00:59:49,760
continue our sessions

1615
00:59:53,670 --> 00:59:52,240
and and for the right

1616
00:59:54,710 --> 00:59:53,680
let's think

1617
00:59:56,309 --> 00:59:54,720
again