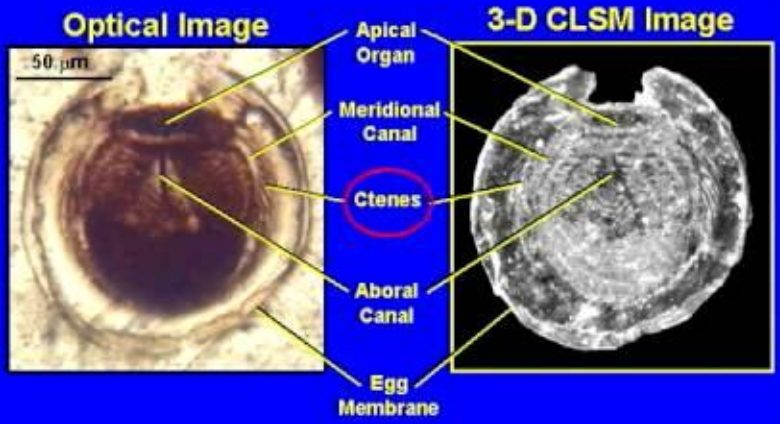
FOSSIL COMB JELLY EMBRYO

(Late-stage, Prior to Hatching)



1
00:00:04,150 --> 00:00:02,230
it really really really is a pleasure to

2
00:00:05,190 --> 00:00:04,160
have you here doing this bill thank you

3
00:00:07,909 --> 00:00:05,200
very much

4
00:00:09,110 --> 00:00:07,919
uh you are indeed a person who needs no

5
00:00:11,030 --> 00:00:09,120
introduction but i'll give you a little

6
00:00:12,070 --> 00:00:11,040
bit of an introduction anyway

7
00:00:14,150 --> 00:00:12,080
um

8
00:00:15,270 --> 00:00:14,160
bill of course is a professor at ucla

9
00:00:18,310 --> 00:00:15,280
and and

10
00:00:20,310 --> 00:00:18,320
bill has probably done more in fact not

11
00:00:22,870 --> 00:00:20,320
probably bill has done more than

12
00:00:24,630 --> 00:00:22,880
probably any other human being on earth

13
00:00:27,750 --> 00:00:24,640

to show us

14
00:00:29,349 --> 00:00:27,760
the antiquity the evidence for antiquity

15
00:00:31,910 --> 00:00:29,359
of life on earth

16
00:00:34,470 --> 00:00:31,920
and for how difficult it is to actually

17
00:00:37,190 --> 00:00:34,480
pull that antiquity and that evidence

18
00:00:40,069 --> 00:00:37,200
out of the ancient rocks on earth

19
00:00:41,830 --> 00:00:40,079
bill is a an organic geochemist and a

20
00:00:45,030 --> 00:00:41,840
paleontologist

21
00:00:47,110 --> 00:00:45,040
who has studied the some of the most

22
00:00:49,190 --> 00:00:47,120
ancient rocks available

23
00:00:51,510 --> 00:00:49,200
and has developed techniques that he's

24
00:00:53,350 --> 00:00:51,520
going to be telling us about today for

25
00:00:54,549 --> 00:00:53,360
pulling this information out of rocks

26
00:00:57,189 --> 00:00:54,559
that i

27
00:01:00,790 --> 00:00:57,199
personally find fascinating and

28
00:01:03,590 --> 00:01:00,800
have enjoyed uh learning about from bill

29
00:01:05,670 --> 00:01:03,600
so it's great that we can share this all

30
00:01:07,670 --> 00:01:05,680
with you i'm really really pleased to

31
00:01:09,510 --> 00:01:07,680
see a fabulous turnout for this event

32
00:01:10,950 --> 00:01:09,520
and bill i think everybody's excited

33
00:01:13,270 --> 00:01:10,960
about hearing from you

34
00:01:16,310 --> 00:01:13,280
and so without further ado we'll turn it

35
00:01:18,550 --> 00:01:16,320
over to bill to tell us whether marx

36
00:01:22,070 --> 00:01:18,560
rocks from mars can yield definitive

37
00:01:24,630 --> 00:01:22,080
evidence of past life question mark

38
00:01:27,270 --> 00:01:24,640

phil to you

39
00:01:30,630 --> 00:01:27,280
thanks carl uh

40
00:01:34,390 --> 00:01:30,640
first off uh it is a real honor

41
00:01:37,670 --> 00:01:34,400
uh to be asked to uh address you folks

42
00:01:39,109 --> 00:01:37,680
and i appreciate carl having uh asked me

43
00:01:40,789 --> 00:01:39,119
to do this

44
00:01:43,590 --> 00:01:40,799
and second

45
00:01:45,990 --> 00:01:43,600
even though your faces are sort of fuzzy

46
00:01:49,109 --> 00:01:46,000
on our screen here

47
00:01:51,429 --> 00:01:49,119
i do detect a number of pals of mine out

48
00:01:54,230 --> 00:01:51,439
there and uh i give you uh

49
00:01:55,990 --> 00:01:54,240
a uh a good morning from uh southern

50
00:01:57,749 --> 00:01:56,000
california

51
00:01:59,109 --> 00:01:57,759
okay um

52
00:02:00,789 --> 00:01:59,119
look uh

53
00:02:02,069 --> 00:02:00,799
yeah i'm gonna try to talk a little bit

54
00:02:05,510 --> 00:02:02,079
about uh

55
00:02:07,429 --> 00:02:05,520
two two new techniques that i think are

56
00:02:08,630 --> 00:02:07,439
gonna be generally useful

57
00:02:11,510 --> 00:02:08,640
not only

58
00:02:12,710 --> 00:02:11,520
for looking at past life on mars but

59
00:02:13,830 --> 00:02:12,720
also

60
00:02:15,589 --> 00:02:13,840
for looking

61
00:02:17,990 --> 00:02:15,599
at evidence of

62
00:02:20,470 --> 00:02:18,000
ancient life on earth

63
00:02:23,430 --> 00:02:20,480

and let me start off by

64
00:02:24,470 --> 00:02:23,440
reminding us of what we already know

65
00:02:26,869 --> 00:02:24,480
uh

66
00:02:27,990 --> 00:02:26,879
the history of life on earth you're all

67
00:02:29,190 --> 00:02:28,000
aware

68
00:02:33,190 --> 00:02:29,200
that

69
00:02:36,710 --> 00:02:33,200
since the mid-1960s the uh fossil record

70
00:02:38,390 --> 00:02:36,720
of uh and geochemical record of life on

71
00:02:40,630 --> 00:02:38,400
earth has been extended back to three

72
00:02:41,990 --> 00:02:40,640
and a half billion years ago

73
00:02:48,309 --> 00:02:42,000
uh

74
00:02:51,190 --> 00:02:48,319
one of the foremost unsolved problems in

75
00:02:53,430 --> 00:02:51,200
natural science well we've made a lot of

76
00:02:55,350 --> 00:02:53,440
progress so you're well aware of that

77
00:02:57,830 --> 00:02:55,360
you know that the precambrian is the age

78
00:03:00,470 --> 00:02:57,840
of microscopic life uh and what we've

79
00:03:02,710 --> 00:03:00,480
learned is that uh life during the

80
00:03:05,830 --> 00:03:02,720
precambrian was dominated by these

81
00:03:08,070 --> 00:03:05,840
microbe level organisms that would in

82
00:03:09,670 --> 00:03:08,080
microbe level life is ubiquitous

83
00:03:11,589 --> 00:03:09,680
abundant diverse

84
00:03:13,670 --> 00:03:11,599
uh it's been predominant over the

85
00:03:16,149 --> 00:03:13,680
history of this planet

86
00:03:18,070 --> 00:03:16,159
and it'll of course exist even if

87
00:03:20,470 --> 00:03:18,080
advanced life

88
00:03:23,430 --> 00:03:20,480

has not yet evolved

89
00:03:26,309 --> 00:03:23,440
just due to evolution so

90
00:03:29,350 --> 00:03:26,319
for the astrobiological search for uh

91
00:03:31,910 --> 00:03:29,360
evidence elsewhere the best analog that

92
00:03:33,509 --> 00:03:31,920
we know of is the micro microbe

93
00:03:35,910 --> 00:03:33,519
dominated earth

94
00:03:37,190 --> 00:03:35,920
uh the precambrian earth so you're all

95
00:03:39,990 --> 00:03:37,200
aware of that

96
00:03:42,470 --> 00:03:40,000
uh and i think many of you will have

97
00:03:43,350 --> 00:03:42,480
been familiar with uh at least some of

98
00:03:46,149 --> 00:03:43,360
the

99
00:03:48,869 --> 00:03:46,159
fossil evidence of ancient life that has

100
00:03:51,509 --> 00:03:48,879
been uncovered here uh some very nicely

101
00:03:54,630 --> 00:03:51,519
preserved cyanobacterial filaments uh

102
00:03:57,670 --> 00:03:54,640
from the precambrian of australia

103
00:04:00,390 --> 00:03:57,680
what you might not be well uh here also

104
00:04:02,390 --> 00:04:00,400
i thought that i'd have to show you that

105
00:04:04,390 --> 00:04:02,400
there is some reason for thinking these

106
00:04:08,309 --> 00:04:04,400
are real organisms uh

107
00:04:11,910 --> 00:04:08,319
uh a a good morphological uh comparison

108
00:04:14,630 --> 00:04:11,920
uh there between uh oscillatory amina a

109
00:04:16,789 --> 00:04:14,640
particular modern species of oscillatory

110
00:04:19,509 --> 00:04:16,799
and a fossil counterpart and

111
00:04:21,830 --> 00:04:19,519
here another species of oscillatory in

112
00:04:23,670 --> 00:04:21,840
the modern and uh and its fossil

113
00:04:26,230 --> 00:04:23,680

counterpart

114
00:04:29,430 --> 00:04:26,240
what you may not uh be

115
00:04:32,070 --> 00:04:29,440
so familiar with is that

116
00:04:34,710 --> 00:04:32,080
these fossils do present problems even

117
00:04:38,550 --> 00:04:34,720
though they're excellently preserved

118
00:04:42,350 --> 00:04:38,560
here for example is a nice

119
00:04:44,070 --> 00:04:42,360
beautifully preserved cellular filamento

120
00:04:45,830 --> 00:04:44,080
cyanobacterium

121
00:04:47,270 --> 00:04:45,840
which you in the the sort of picture

122
00:04:49,510 --> 00:04:47,280
that you would see published in a

123
00:04:51,350 --> 00:04:49,520
scientific publication

124
00:04:52,150 --> 00:04:51,360
but what you might not be aware of is

125
00:04:58,870 --> 00:04:52,160
that

126
00:05:01,749 --> 00:04:58,880
are so small

127
00:05:04,230 --> 00:05:01,759
that one has to use a high uh

128
00:05:07,350 --> 00:05:04,240
magnification 100x oil immersion

129
00:05:09,350 --> 00:05:07,360
objective and as you uh for light

130
00:05:12,710 --> 00:05:09,360
optical microscopy and as you do that of

131
00:05:14,310 --> 00:05:12,720
course the focal plane becomes uh

132
00:05:16,870 --> 00:05:14,320
more and more thin

133
00:05:17,749 --> 00:05:16,880
and the only way that you can show

134
00:05:21,029 --> 00:05:17,759
such

135
00:05:23,029 --> 00:05:21,039
fossils that plunge down into the rock

136
00:05:26,230 --> 00:05:23,039
in this particular example

137
00:05:27,830 --> 00:05:26,240
down to some 20 microns or so

138
00:05:29,670 --> 00:05:27,840

is to uh

139
00:05:31,830 --> 00:05:29,680
to take a set of photographs and then

140
00:05:33,990 --> 00:05:31,840
paste them together

141
00:05:36,710 --> 00:05:34,000
to make a photo montage and here is such

142
00:05:39,749 --> 00:05:36,720
a photo montage another technique we've

143
00:05:41,270 --> 00:05:39,759
used has been to make interpretive

144
00:05:42,950 --> 00:05:41,280
drawings

145
00:05:45,350 --> 00:05:42,960
well i've never really been very

146
00:05:48,070 --> 00:05:45,360
satisfied with these these uh i

147
00:05:49,270 --> 00:05:48,080
developed both of them and

148
00:05:51,830 --> 00:05:49,280
i just

149
00:05:54,550 --> 00:05:51,840
have never really liked them very much

150
00:05:57,029 --> 00:05:54,560
because of the subjectivity involved

151
00:05:58,710 --> 00:05:57,039
and so for a long time about 40 years

152
00:06:00,469 --> 00:05:58,720
i've been looking for a technique that

153
00:06:04,390 --> 00:06:00,479
would permit me

154
00:06:06,870 --> 00:06:04,400
to image microscopic fossils inside

155
00:06:09,189 --> 00:06:06,880
rocks in three dimensions

156
00:06:11,830 --> 00:06:09,199
well uh in the last three or four years

157
00:06:14,390 --> 00:06:11,840
we've come up with a a reasonably good

158
00:06:16,070 --> 00:06:14,400
system to do this confocal laser

159
00:06:18,150 --> 00:06:16,080
scanning microscopy and that's one of

160
00:06:21,189 --> 00:06:18,160
the techniques that i want to introduce

161
00:06:25,510 --> 00:06:21,199
to you today uh this it's a simple

162
00:06:28,550 --> 00:06:25,520
technique uh laser uh light impinges on

163
00:06:31,270 --> 00:06:28,560

the microscopic fossils are composed of

164
00:06:33,830 --> 00:06:31,280
polycyclic aromatic hydrocarbons they

165
00:06:36,550 --> 00:06:33,840
have organic walls that

166
00:06:38,790 --> 00:06:36,560
the laser excites fluorescence in that

167
00:06:42,070 --> 00:06:38,800
back scattered fluorescence is then

168
00:06:45,749 --> 00:06:42,080
picked up by the detector and uh you uh

169
00:06:49,510 --> 00:06:45,759
scan through these uh fossils oh say at

170
00:06:51,029 --> 00:06:49,520
50 nanometer um two-dimensional images

171
00:06:54,150 --> 00:06:51,039
and then the computer will put them back

172
00:06:58,230 --> 00:06:54,160
together for a three-dimensional image

173
00:07:01,390 --> 00:06:58,240
this is a technique that was first used

174
00:07:04,870 --> 00:07:01,400
to and was developed to look at the

175
00:07:07,670 --> 00:07:04,880
cytoskeletons of individual cells

176
00:07:09,749 --> 00:07:07,680
of living organisms using fluorescent

177
00:07:11,909 --> 00:07:09,759
dyes and cannot die

178
00:07:12,870 --> 00:07:11,919
uh you cannot put a fluorescent dye into

179
00:07:15,749 --> 00:07:12,880
a rock

180
00:07:18,550 --> 00:07:15,759
uh to have it react with fossils but it

181
00:07:22,629 --> 00:07:18,560
turns out that the organic matter the

182
00:07:27,510 --> 00:07:24,390
will in fact

183
00:07:28,950 --> 00:07:27,520
fluoresce if you use the right laser uh

184
00:07:32,070 --> 00:07:28,960
frequency

185
00:07:34,469 --> 00:07:32,080
so here uh is that same filament shown

186
00:07:37,189 --> 00:07:34,479
below in an optical photomicrograph now

187
00:07:40,790 --> 00:07:37,199
mr marco is now going to put a little

188
00:07:43,350 --> 00:07:40,800

hand on that picture at the top and it's

189
00:07:45,270 --> 00:07:43,360
going to rotate i think

190
00:07:47,670 --> 00:07:45,280
hello mr marco

191
00:07:50,150 --> 00:07:47,680
my good friend mr marco

192
00:07:54,390 --> 00:07:50,160
is going to make the

193
00:07:57,830 --> 00:07:54,400
the filament at the top rotate

194
00:08:00,550 --> 00:07:57,840
uh and there goes mr marco uh he's going

195
00:08:03,110 --> 00:08:00,560
the one at the top and there it comes

196
00:08:05,990 --> 00:08:03,120
and it is going to spin around before

197
00:08:07,350 --> 00:08:06,000
your very eyes there it goes my goodness

198
00:08:10,390 --> 00:08:07,360
gracious

199
00:08:12,469 --> 00:08:10,400
um you're looking down into a thin

200
00:08:16,070 --> 00:08:12,479
section of rock this is a rock embedded

201
00:08:18,070 --> 00:08:16,080
uh carriage and composed cell wall

202
00:08:20,070 --> 00:08:18,080
microorganisms you can spin it one more

203
00:08:22,869 --> 00:08:20,080
time it's real pretty

204
00:08:25,189 --> 00:08:22,879
and you can see the individual cells in

205
00:08:30,150 --> 00:08:28,230
down there at the left-hand end and you

206
00:08:34,550 --> 00:08:30,160
can also see the three-dimensionality of

207
00:08:37,269 --> 00:08:34,560
it as it plunges down into the rock okay

208
00:08:39,029 --> 00:08:37,279
we're now going to try to go back to

209
00:08:43,269 --> 00:08:39,039
the original

210
00:08:44,790 --> 00:08:43,279
there we go and into the yeah now i'm

211
00:08:47,110 --> 00:08:44,800
going to fill the screen with this thing

212
00:08:50,470 --> 00:08:47,120
miraculously it says here

213
00:08:53,750 --> 00:08:50,480

uh it's alternate and

214
00:08:56,230 --> 00:08:53,760
end alternative and something alternate

215
00:08:59,350 --> 00:08:56,240
and enter there we go

216
00:09:02,310 --> 00:08:59,360
okay so that's just one example uh

217
00:09:04,990 --> 00:09:02,320
here's another example uh of the the

218
00:09:07,030 --> 00:09:05,000
upper row is a set of optical

219
00:09:08,790 --> 00:09:07,040
photomicrographs of a spheroidal

220
00:09:11,269 --> 00:09:08,800
microscopic fossil

221
00:09:13,590 --> 00:09:11,279
uh the upper surface sort of the north

222
00:09:15,829 --> 00:09:13,600
pole the medial planes the equatorial

223
00:09:19,110 --> 00:09:15,839
plane and the lower surface is the south

224
00:09:21,430 --> 00:09:19,120
pole down beneath that is a confocal

225
00:09:23,430 --> 00:09:21,440
image a still image of that same

226
00:09:24,949 --> 00:09:23,440
specimen

227
00:09:27,509 --> 00:09:24,959
and here

228
00:09:28,870 --> 00:09:27,519
uh a comparison on the left of an

229
00:09:30,470 --> 00:09:28,880
optical photomicrograph of the

230
00:09:33,350 --> 00:09:30,480
equatorial plane

231
00:09:36,790 --> 00:09:33,360
and on the right uh the confocal image

232
00:09:39,269 --> 00:09:36,800
which mr marco note before we go

233
00:09:43,030 --> 00:09:39,279
that uh there's an outer envelope and an

234
00:09:44,710 --> 00:09:43,040
inner envelope uh and now mr marco is

235
00:09:47,110 --> 00:09:44,720
going to put the little hand on it or

236
00:09:50,310 --> 00:09:47,120
something and get it to rotate for us

237
00:09:52,310 --> 00:09:50,320
it's inside a piece of rock and he has

238
00:09:54,230 --> 00:09:52,320

got to do a whole bunch of manipulations

239
00:09:55,350 --> 00:09:54,240
and there he manipulated right before

240
00:09:56,710 --> 00:09:55,360
our eyes

241
00:10:01,509 --> 00:09:56,720
and now that thing's going to spin

242
00:10:07,110 --> 00:10:03,670
it's going to spin around yes it's

243
00:10:10,230 --> 00:10:07,120
loading it there it goes um

244
00:10:12,790 --> 00:10:10,240
uh this the resolution here is really

245
00:10:14,630 --> 00:10:12,800
appreciably better you can spin it one

246
00:10:15,509 --> 00:10:14,640
more time if it keeps going there it

247
00:10:17,190 --> 00:10:15,519
goes

248
00:10:19,269 --> 00:10:17,200
is appreciably better than you can get

249
00:10:24,790 --> 00:10:19,279
by optical microscopy

250
00:10:29,430 --> 00:10:26,630
we've artificially colored it so you can

251
00:10:31,750 --> 00:10:29,440
see the the wall layers and the sheets

252
00:10:34,150 --> 00:10:31,760
and so forth in it okay that's that's

253
00:10:36,949 --> 00:10:34,160
enough of that one thank you very much

254
00:10:38,389 --> 00:10:36,959
marco you're doing excellent work for us

255
00:10:40,150 --> 00:10:38,399
okay

256
00:10:41,350 --> 00:10:40,160
now i'm going to try that again all

257
00:10:43,590 --> 00:10:41,360
right

258
00:10:46,870 --> 00:10:43,600
uh here then uh

259
00:10:49,350 --> 00:10:46,880
our is another uh such uh microfossil

260
00:10:52,069 --> 00:10:49,360
medial plane on the left and the north

261
00:10:54,870 --> 00:10:52,079
pole on the upper surface on the right

262
00:10:58,550 --> 00:10:54,880
and you can see the difference between

263
00:11:02,389 --> 00:10:58,560

the stills picture of a confocal image

264
00:11:05,670 --> 00:11:02,399
uh it's much more detailed and gives a

265
00:11:07,670 --> 00:11:05,680
lot more taxonomic and taffenomic

266
00:11:08,790 --> 00:11:07,680
information that people like myself can

267
00:11:09,910 --> 00:11:08,800
use

268
00:11:13,269 --> 00:11:09,920
um

269
00:11:15,910 --> 00:11:13,279
now something's going on

270
00:11:18,949 --> 00:11:15,920
it says quit install

271
00:11:21,269 --> 00:11:18,959
oh my goodness we okay thank you

272
00:11:23,269 --> 00:11:21,279
uh one more example this is kind of

273
00:11:24,150 --> 00:11:23,279
interesting the one at the far left is

274
00:11:26,949 --> 00:11:24,160
the

275
00:11:29,110 --> 00:11:26,959
thin section upper surface just a little

276
00:11:31,430 --> 00:11:29,120
bit below that is the medial plane and

277
00:11:34,150 --> 00:11:31,440
then the lower south pole is shown on

278
00:11:35,829 --> 00:11:34,160
this this is a a sphere that uh

279
00:11:36,710 --> 00:11:35,839
intersected 10

280
00:11:40,230 --> 00:11:36,720
10

281
00:11:41,750 --> 00:11:40,240
uh was cut by uh the upper surface of

282
00:11:42,550 --> 00:11:41,760
the thin section

283
00:11:44,790 --> 00:11:42,560
so

284
00:11:47,990 --> 00:11:44,800
uh now in the confocal picture on the

285
00:11:51,509 --> 00:11:48,000
left we're looking inside it and imaging

286
00:11:53,509 --> 00:11:51,519
the inside of the lower surface uh of

287
00:11:55,350 --> 00:11:53,519
that sphere and you can tilt the thing

288
00:11:57,110 --> 00:11:55,360

and you can see that it indeed is cup

289
00:11:58,949 --> 00:11:57,120
shape where it's been cut at the upper

290
00:12:00,470 --> 00:11:58,959
surface of the thin section

291
00:12:02,710 --> 00:12:00,480
all right well the question then is you

292
00:12:06,550 --> 00:12:02,720
get a good morphological way to look at

293
00:12:08,949 --> 00:12:06,560
these fossils uh inside rocks uh very

294
00:12:12,150 --> 00:12:08,959
tiny ones indeed but can you match that

295
00:12:13,990 --> 00:12:12,160
with uh with chemistry and the solution

296
00:12:15,190 --> 00:12:14,000
we've come up with is using raman

297
00:12:15,990 --> 00:12:15,200
imagery

298
00:12:18,550 --> 00:12:16,000
uh

299
00:12:21,190 --> 00:12:18,560
ramen imagery is rather like it's based

300
00:12:24,310 --> 00:12:21,200
on of course uh normal uh raman

301
00:12:26,470 --> 00:12:24,320
spectroscopy which gets point spectra of

302
00:12:29,509 --> 00:12:26,480
a specimen but in this case

303
00:12:31,030 --> 00:12:29,519
the uh laser scans across

304
00:12:32,230 --> 00:12:31,040
uh

305
00:12:35,190 --> 00:12:32,240
making a

306
00:12:39,030 --> 00:12:35,200
a large a very large array

307
00:12:42,470 --> 00:12:39,040
uh in two dimensions of the material

308
00:12:44,389 --> 00:12:42,480
image and then you stack those up

309
00:12:47,269 --> 00:12:44,399
to get a three-dimensional image you

310
00:12:49,829 --> 00:12:47,279
stack them up with a computer program

311
00:12:54,710 --> 00:12:49,839
the way ramen works is that

312
00:12:57,590 --> 00:12:55,509
is

313
00:12:58,710 --> 00:12:57,600

simply scattered by normal rayleigh

314
00:13:01,269 --> 00:12:58,720
scattering

315
00:13:03,430 --> 00:13:01,279
without any change in frequency but

316
00:13:05,990 --> 00:13:03,440
a small amount of that energy is

317
00:13:08,470 --> 00:13:06,000
absorbed in the bonds of the material

318
00:13:10,069 --> 00:13:08,480
you're analyzing whether it's in liquid

319
00:13:14,470 --> 00:13:10,079
phase or

320
00:13:15,509 --> 00:13:14,480
these of course are in solid phase in

321
00:13:16,389 --> 00:13:15,519
rocks

322
00:13:17,350 --> 00:13:16,399
and

323
00:13:19,269 --> 00:13:17,360
the

324
00:13:21,590 --> 00:13:19,279
little energy is absorbed and you get a

325
00:13:24,710 --> 00:13:21,600
shift in the spectrum of light

326
00:13:27,110 --> 00:13:24,720
uh that is back scattered or detected by

327
00:13:29,350 --> 00:13:27,120
the back scattered light uh related to

328
00:13:30,870 --> 00:13:29,360
the vibrational transition transitions

329
00:13:33,110 --> 00:13:30,880
that characterizes the material you're

330
00:13:34,550 --> 00:13:33,120
analyzing now you can analyze minerals

331
00:13:35,990 --> 00:13:34,560
this way and that's normally what it's

332
00:13:37,430 --> 00:13:36,000
used for

333
00:13:39,269 --> 00:13:37,440
geologically

334
00:13:41,350 --> 00:13:39,279
but you can also analyze the organic

335
00:13:42,790 --> 00:13:41,360
matter of fossils so here's that same

336
00:13:45,430 --> 00:13:42,800
specimen

337
00:13:46,710 --> 00:13:45,440
a interpretive drawing and a nice

338
00:13:48,949 --> 00:13:46,720

clsm

339
00:13:51,190 --> 00:13:48,959
image at the bottom and now coming in

340
00:13:52,389 --> 00:13:51,200
from the right hand side

341
00:13:56,310 --> 00:13:52,399
is

342
00:13:57,269 --> 00:13:56,320
the tip of that filament

343
00:14:01,189 --> 00:13:57,279
it

344
00:14:04,470 --> 00:14:01,199
thin section but the image you're seeing

345
00:14:07,030 --> 00:14:04,480
there is a three-dimensional ramen image

346
00:14:10,230 --> 00:14:07,040
uh not it's a chemical image that uh

347
00:14:12,870 --> 00:14:10,240
with all the dark material uh

348
00:14:14,790 --> 00:14:12,880
i don't know whether i can show you

349
00:14:18,870 --> 00:14:14,800
on this screen but not on that screen i

350
00:14:21,430 --> 00:14:18,880
guess uh the uh the the dark material is

351
00:14:24,069 --> 00:14:21,440
kerogen making up the cell walls

352
00:14:27,110 --> 00:14:24,079
and the light material inside of course

353
00:14:29,030 --> 00:14:27,120
is the the chirp the quartz that infill

354
00:14:31,189 --> 00:14:29,040
such cells and you also get that on the

355
00:14:33,269 --> 00:14:31,199
outside as well you can see the raman

356
00:14:35,269 --> 00:14:33,279
spectrum characterizing the

357
00:14:36,150 --> 00:14:35,279
the uh the kerogen

358
00:14:45,189 --> 00:14:36,160
uh

359
00:14:47,910 --> 00:14:45,199
image of a an oscillatory asian

360
00:14:49,829 --> 00:14:47,920
cyanobacterial filament

361
00:14:52,310 --> 00:14:49,839
compared with an optical picture in the

362
00:14:54,629 --> 00:14:52,320
middle and a modern trichome on modern

363
00:14:56,790 --> 00:14:54,639

organism above

364
00:15:00,069 --> 00:14:56,800
and that image at the bottom

365
00:15:02,949 --> 00:15:00,079
a marco will spin around

366
00:15:04,389 --> 00:15:02,959
that is the new full lifesaver

367
00:15:06,150 --> 00:15:04,399
uh

368
00:15:07,750 --> 00:15:06,160
and it's rather pretty

369
00:15:09,509 --> 00:15:07,760
and you can see the individual disc

370
00:15:10,790 --> 00:15:09,519
shaped cells

371
00:15:12,470 --> 00:15:10,800
and

372
00:15:14,710 --> 00:15:12,480
it will spin around

373
00:15:16,470 --> 00:15:14,720
it will come up uh

374
00:15:19,350 --> 00:15:16,480
at least i've got it here but you don't

375
00:15:24,150 --> 00:15:21,590
now i can see it on my screen but you

376
00:15:27,030 --> 00:15:24,160
can't see it on yours i don't think well

377
00:15:28,629 --> 00:15:27,040
take my word for it folks it is really

378
00:15:31,110 --> 00:15:28,639
pretty

379
00:15:32,790 --> 00:15:31,120
you see it over here oh you can okay

380
00:15:33,750 --> 00:15:32,800
well our screen's blank

381
00:15:36,550 --> 00:15:33,760
okay

382
00:15:38,790 --> 00:15:36,560
so let's go let's go back to uh where we

383
00:15:43,350 --> 00:15:38,800
were before and uh

384
00:15:45,269 --> 00:15:43,360
we will again go to full screen here

385
00:15:53,030 --> 00:15:45,279
and

386
00:16:00,150 --> 00:15:55,509
i seem to be

387
00:16:16,310 --> 00:16:01,030
i

388
00:16:18,629 --> 00:16:16,320

now at the bottom left and a clsm

389
00:16:23,030 --> 00:16:18,639
picture of it and so you can get an idea

390
00:16:24,870 --> 00:16:23,040
of how these ramen images are made

391
00:16:33,590 --> 00:16:24,880
the

392
00:16:38,550 --> 00:16:33,600
imaged chemically by raman spectroscopy

393
00:16:43,030 --> 00:16:41,350
we're not going to go to uh

394
00:16:47,990 --> 00:16:43,040
to

395
00:16:50,150 --> 00:16:48,000
but

396
00:16:51,350 --> 00:16:50,160
these both will spin around and you can

397
00:16:54,389 --> 00:16:51,360
compare

398
00:16:56,470 --> 00:16:54,399
uh the detailed morphology uh of the

399
00:16:57,430 --> 00:16:56,480
chemistry with the detailed morphology

400
00:16:59,749 --> 00:16:57,440
of the

401
00:17:01,509 --> 00:16:59,759
fluorescence and uh it turns out to be

402
00:17:04,549 --> 00:17:01,519
quite instructive

403
00:17:07,990 --> 00:17:04,559
uh you should note here that uh the clsm

404
00:17:10,069 --> 00:17:08,000
gives a appreciably better resolution on

405
00:17:11,189 --> 00:17:10,079
the order of uh three tenths of a micron

406
00:17:14,390 --> 00:17:11,199
or less

407
00:17:17,429 --> 00:17:14,400
whereas ramen is around 0.9 our ramen

408
00:17:19,990 --> 00:17:17,439
system is about 0.9 microns

409
00:17:21,750 --> 00:17:20,000
but both of them are sub micron

410
00:17:24,069 --> 00:17:21,760
resolution and that's what you need to

411
00:17:25,029 --> 00:17:24,079
work on microscopic fossils

412
00:17:28,150 --> 00:17:25,039
okay

413
00:17:29,510 --> 00:17:28,160

well a question that is sometimes asked

414
00:17:32,549 --> 00:17:29,520
me

415
00:17:35,110 --> 00:17:32,559
is how do you know that those things are

416
00:17:37,190 --> 00:17:35,120
really uh

417
00:17:38,230 --> 00:17:37,200
organisms how do you know that there you

418
00:17:40,390 --> 00:17:38,240
claim

419
00:17:42,710 --> 00:17:40,400
uh that these things are

420
00:17:45,590 --> 00:17:42,720
oscillatory

421
00:17:47,590 --> 00:17:45,600
just like the modern modern genus well

422
00:17:49,430 --> 00:17:47,600
how do you know that on what basis do

423
00:17:50,710 --> 00:17:49,440
you make that assertion

424
00:17:52,710 --> 00:17:50,720
well there's a

425
00:17:55,029 --> 00:17:52,720
comparison of a modern one and a fossil

426
00:17:56,950 --> 00:17:55,039
one up above but there are three uh

427
00:17:58,549 --> 00:17:56,960
principal characteristics rounded

428
00:18:01,990 --> 00:17:58,559
terminal cells

429
00:18:04,070 --> 00:18:02,000
disc shaped medial cells and partial

430
00:18:05,669 --> 00:18:04,080
septations and the question then do

431
00:18:07,909 --> 00:18:05,679
these techniques help us there well it

432
00:18:09,430 --> 00:18:07,919
turns out we can see a lot more using

433
00:18:12,230 --> 00:18:09,440
these techniques and you can see

434
00:18:16,150 --> 00:18:12,240
optically so with regard to rounded

435
00:18:19,909 --> 00:18:16,160
terminal cells uh here uh you can see a

436
00:18:23,590 --> 00:18:19,919
blow up of a clsm image of uh

437
00:18:26,070 --> 00:18:23,600
the tip of that uh fossil filament

438
00:18:29,190 --> 00:18:26,080

and if the arrows and stuff that were

439
00:18:30,310 --> 00:18:29,200
here before it got onto this blasted

440
00:18:33,590 --> 00:18:30,320
system

441
00:18:35,510 --> 00:18:33,600
there would be arrows pointing to the

442
00:18:38,070 --> 00:18:35,520
terminal cells and you'd be able to i'd

443
00:18:40,470 --> 00:18:38,080
be able to convince you that yes indeed

444
00:18:44,549 --> 00:18:40,480
you can see the terminal cells much

445
00:18:46,470 --> 00:18:44,559
better with clsm than you can optically

446
00:18:49,270 --> 00:18:46,480
in this one you would have been you can

447
00:18:51,110 --> 00:18:49,280
see the medial cells uh they're to the

448
00:18:53,190 --> 00:18:51,120
right of the terminal cells which indeed

449
00:18:57,750 --> 00:18:53,200
are disc shaped uh

450
00:19:00,310 --> 00:18:57,760
here uh a clsm image of another part the

451
00:19:02,310 --> 00:19:00,320
middle part of that filament again nice

452
00:19:05,510 --> 00:19:02,320
disc shaped shells which are better uh

453
00:19:06,390 --> 00:19:05,520
defined by the clsm this is all inside a

454
00:19:07,190 --> 00:19:06,400
rock

455
00:19:08,710 --> 00:19:07,200
uh

456
00:19:11,510 --> 00:19:08,720
and then these things called partial

457
00:19:13,909 --> 00:19:11,520
septations oh this is really too bad

458
00:19:15,990 --> 00:19:13,919
well there are a set of arrows that

459
00:19:17,510 --> 00:19:16,000
somehow are not on the system i don't

460
00:19:20,070 --> 00:19:17,520
know where they went oh they're hidden

461
00:19:22,390 --> 00:19:20,080
behind i can see their tops and there's

462
00:19:24,870 --> 00:19:22,400
no way i don't think for me to point to

463
00:19:26,070 --> 00:19:24,880

them but you look at the modern filament

464
00:19:28,710 --> 00:19:26,080
up above

465
00:19:31,350 --> 00:19:28,720
uh you can see the cell walls and then

466
00:19:33,750 --> 00:19:31,360
uh halfway in between each of the cell

467
00:19:35,510 --> 00:19:33,760
walls which are continuous through the

468
00:19:36,470 --> 00:19:35,520
the filament there are these little

469
00:19:40,310 --> 00:19:36,480
ticks

470
00:19:41,909 --> 00:19:40,320
coming in from the bottom uh they're

471
00:19:43,669 --> 00:19:41,919
symmetrical well those are called

472
00:19:45,190 --> 00:19:43,679
partial septations

473
00:19:46,950 --> 00:19:45,200
and by golly

474
00:19:47,669 --> 00:19:46,960
now at least you can see a little bit of

475
00:19:50,150 --> 00:19:47,679
them

476
00:19:52,390 --> 00:19:50,160
uh this is a drawing based on a

477
00:19:54,310 --> 00:19:52,400
transmission electron micrograph

478
00:19:55,909 --> 00:19:54,320
and you can see the partial septations

479
00:19:58,549 --> 00:19:55,919
coming in from the sides and that's the

480
00:20:01,350 --> 00:19:58,559
way these cells reproduce that is the

481
00:20:03,590 --> 00:20:01,360
the two two edges merge in the middle of

482
00:20:05,909 --> 00:20:03,600
the cell now you've got two cells and so

483
00:20:07,909 --> 00:20:05,919
forth we can hardly see these in fact

484
00:20:11,029 --> 00:20:07,919
they've never ever been reported from

485
00:20:13,270 --> 00:20:11,039
fossils before this specimen

486
00:20:15,110 --> 00:20:13,280
and here you see with those nice little

487
00:20:17,350 --> 00:20:15,120
blue arrows that here you can actually

488
00:20:18,230 --> 00:20:17,360

see them

489
00:20:21,830 --> 00:20:18,240
that

490
00:20:24,789 --> 00:20:21,840
the thin lines in between the thicker

491
00:20:27,510 --> 00:20:24,799
cell walls those are partial septations

492
00:20:29,510 --> 00:20:27,520
uh another example shown here

493
00:20:32,470 --> 00:20:29,520
uh from the back end the right end of

494
00:20:34,789 --> 00:20:32,480
that filament uh beautiful partial

495
00:20:36,789 --> 00:20:34,799
septations three of them on the left but

496
00:20:38,470 --> 00:20:36,799
you can rotate these specimens too and

497
00:20:39,830 --> 00:20:38,480
so we've rotated

498
00:20:42,870 --> 00:20:39,840
that same

499
00:20:45,350 --> 00:20:42,880
image to look at it from the side

500
00:20:46,950 --> 00:20:45,360
on the right right side you can see and

501
00:20:48,710 --> 00:20:46,960
then if you want to know for sure what

502
00:20:50,630 --> 00:20:48,720
their chemistry is

503
00:20:52,789 --> 00:20:50,640
you do raman spectroscopy

504
00:20:55,110 --> 00:20:52,799
three-dimensional imaging of the same

505
00:20:56,870 --> 00:20:55,120
part of the same specimen

506
00:20:58,390 --> 00:20:56,880
and you can see the partial septations

507
00:21:01,350 --> 00:20:58,400
they're made out of carriage and just as

508
00:21:03,110 --> 00:21:01,360
you would have expected them to be

509
00:21:04,950 --> 00:21:03,120
okay well those are the two techniques

510
00:21:07,350 --> 00:21:04,960
that i wanted to to introduce and you

511
00:21:11,270 --> 00:21:07,360
have to ask yourself the question why do

512
00:21:13,110 --> 00:21:11,280
clsm and ramen work on rock embedded

513
00:21:17,590 --> 00:21:13,120

fossils

514
00:21:19,590 --> 00:21:17,600
uh that hadn't been done before so why

515
00:21:21,669 --> 00:21:19,600
what's the basis well

516
00:21:23,669 --> 00:21:21,679
uh life of course is made of chance

517
00:21:25,029 --> 00:21:23,679
carbon hydrogen oxygen nitrogen sulfur

518
00:21:26,270 --> 00:21:25,039
and phosphorus

519
00:21:29,029 --> 00:21:26,280
uh

520
00:21:30,789 --> 00:21:29,039
microorganisms enzymes break down that

521
00:21:32,950 --> 00:21:30,799
organic matter and you get sort of a

522
00:21:35,350 --> 00:21:32,960
proto-keratin and rocks made mostly of

523
00:21:36,870 --> 00:21:35,360
carbon and hydrogen little oxygen not

524
00:21:39,029 --> 00:21:36,880
much nitrogen

525
00:21:42,070 --> 00:21:39,039
uh with burial and heating you get lost

526
00:21:44,950 --> 00:21:42,080
loss of oxygen and nitrogen and uh end

527
00:21:46,630 --> 00:21:44,960
up with essentially uh carbon and

528
00:21:49,029 --> 00:21:46,640
hydrogen only

529
00:21:50,470 --> 00:21:49,039
uh in the form of polycyclic aromatic

530
00:21:52,470 --> 00:21:50,480
hydrocarbons

531
00:21:54,710 --> 00:21:52,480
and then of course that same material

532
00:21:56,950 --> 00:21:54,720
and polycyclics are

533
00:21:59,430 --> 00:21:56,960
platey molecules and they're on the way

534
00:22:01,590 --> 00:21:59,440
toward graphite so if you keep with

535
00:22:02,870 --> 00:22:01,600
metamorphic heating you'll end up just

536
00:22:05,270 --> 00:22:02,880
with carbon

537
00:22:07,909 --> 00:22:05,280
well these polycyclics are based on a

538
00:22:09,990 --> 00:22:07,919

benzene ring type of material

539
00:22:12,070 --> 00:22:10,000
type of compounds where you get

540
00:22:14,310 --> 00:22:12,080
ring conjugated alternating single

541
00:22:16,230 --> 00:22:14,320
double bonds which spread out the pi

542
00:22:19,510 --> 00:22:16,240
electrons and consequently give these

543
00:22:21,750 --> 00:22:19,520
things a particularly uh stable

544
00:22:23,190 --> 00:22:21,760
configuration

545
00:22:25,750 --> 00:22:23,200
in

546
00:22:28,710 --> 00:22:25,760
the material that which fossils are

547
00:22:30,470 --> 00:22:28,720
composed uh these uh

548
00:22:32,710 --> 00:22:30,480
they're polycyclic

549
00:22:36,470 --> 00:22:32,720
compounds made up of

550
00:22:38,830 --> 00:22:36,480
multiple arrays of uh these six-membered

551
00:22:41,830 --> 00:22:38,840
rings with hydrogen just at the

552
00:22:43,990 --> 00:22:41,840
periphery and of course in kerogens

553
00:22:46,390 --> 00:22:44,000
kerogens really are very complicated

554
00:22:47,830 --> 00:22:46,400
molecules it's not really a molecule

555
00:22:50,390 --> 00:22:47,840
it's sort of a mass of a whole bunch of

556
00:22:51,909 --> 00:22:50,400
molecules uh put together with their

557
00:22:54,310 --> 00:22:51,919
interlinked

558
00:22:55,830 --> 00:22:54,320
all these polycyclics but the point is

559
00:22:57,029 --> 00:22:55,840
it doesn't matter what you start with it

560
00:22:59,909 --> 00:22:57,039
doesn't matter whether you start with a

561
00:23:01,590 --> 00:22:59,919
carbohydrate uh like cellulose or with

562
00:23:03,990 --> 00:23:01,600
proteins uh

563
00:23:07,909 --> 00:23:04,000

like peptide glycans and bacterial cell

564
00:23:09,750 --> 00:23:07,919
walls uh whether you start with dna or

565
00:23:12,950 --> 00:23:09,760
sugars or whatever you're always going

566
00:23:15,270 --> 00:23:12,960
to end up in this stable configuration

567
00:23:17,430 --> 00:23:15,280
of polycyclic material which is called

568
00:23:19,669 --> 00:23:17,440
carriage in the insoluble organic matter

569
00:23:21,590 --> 00:23:19,679
in ancient sediments

570
00:23:23,029 --> 00:23:21,600
well fossils are made out of that

571
00:23:25,270 --> 00:23:23,039
polycyclic

572
00:23:28,870 --> 00:23:25,280
hydrocarbon material

573
00:23:31,830 --> 00:23:28,880
in clsm the detection of

574
00:23:34,390 --> 00:23:31,840
is of the fluorescence

575
00:23:36,710 --> 00:23:34,400
excited in those pahs

576
00:23:39,909 --> 00:23:36,720
ramen however detects the bonding in the

577
00:23:41,750 --> 00:23:39,919
pah as its molecular structure and ramen

578
00:23:43,830 --> 00:23:41,760
documents the

579
00:23:47,669 --> 00:23:43,840
the uh transition

580
00:23:49,830 --> 00:23:47,679
of small pahs to large pahs to graphite

581
00:23:52,470 --> 00:23:49,840
the alternation the alteration that

582
00:23:55,190 --> 00:23:52,480
accompanies geochemical maturity and

583
00:23:56,870 --> 00:23:55,200
that turns out to be really important if

584
00:23:58,789 --> 00:23:56,880
you want to be sure that you're working

585
00:24:02,230 --> 00:23:58,799
on real fossils not something that's

586
00:24:04,710 --> 00:24:02,240
been introduced later in geological time

587
00:24:07,830 --> 00:24:04,720
i'll come back to that all right well

588
00:24:09,669 --> 00:24:07,840

both of these are rock penetrating um

589
00:24:12,630 --> 00:24:09,679
techniques uh they're not surface

590
00:24:15,430 --> 00:24:12,640
dependent like sims or iron microprobe

591
00:24:17,190 --> 00:24:15,440
or electron microprobe or whatever they

592
00:24:20,070 --> 00:24:17,200
both are non-intrusive and

593
00:24:23,350 --> 00:24:22,310
as you see they don't disturb the fossil

594
00:24:25,750 --> 00:24:23,360
at all

595
00:24:27,430 --> 00:24:25,760
they're both confocal so they can give

596
00:24:29,510 --> 00:24:27,440
accurate two and three-dimensional

597
00:24:31,510 --> 00:24:29,520
images they both use standard

598
00:24:34,070 --> 00:24:31,520
preparations like rock thin sections

599
00:24:36,310 --> 00:24:34,080
which are going to be made for uh

600
00:24:38,230 --> 00:24:36,320
prepared for petrographic studies of

601
00:24:39,990 --> 00:24:38,240
return

602
00:24:42,950 --> 00:24:40,000
martian material

603
00:24:44,870 --> 00:24:42,960
they both give sub micron resolution and

604
00:24:47,830 --> 00:24:44,880
as you've seen now repeatedly they can

605
00:24:50,310 --> 00:24:47,840
be used to analyze the same specimen in

606
00:24:52,470 --> 00:24:50,320
a in a piece of rock and because of that

607
00:24:54,390 --> 00:24:52,480
you get replica data and you have ways

608
00:24:56,149 --> 00:24:54,400
to check one against the other one

609
00:24:58,390 --> 00:24:56,159
against the other we're very fortunate

610
00:25:00,149 --> 00:24:58,400
here i think we're the only lab in fact

611
00:25:02,390 --> 00:25:00,159
i know we're the only lab in the world

612
00:25:04,710 --> 00:25:02,400
that has both of these systems up and

613
00:25:07,269 --> 00:25:04,720

running and so we play them back and

614
00:25:09,669 --> 00:25:07,279
forth and back and forth all the time

615
00:25:11,669 --> 00:25:09,679
which gives us a real advantage uh in

616
00:25:14,710 --> 00:25:11,679
figuring out uh the composition and

617
00:25:15,909 --> 00:25:14,720
morphology and so forth of these fossils

618
00:25:17,750 --> 00:25:15,919
for carbon

619
00:25:19,830 --> 00:25:17,760
carbonaceous fossils it detects the

620
00:25:22,549 --> 00:25:19,840
laser-induced fluorescence

621
00:25:24,710 --> 00:25:22,559
of the fossil organics and raman of

622
00:25:26,710 --> 00:25:24,720
course

623
00:25:28,870 --> 00:25:26,720
measures the molecular structure in a

624
00:25:31,190 --> 00:25:28,880
state of preservation so the two are

625
00:25:33,190 --> 00:25:31,200
complementary

626
00:25:36,549 --> 00:25:33,200
and in terms of strengths and weaknesses

627
00:25:38,870 --> 00:25:36,559
clsm has a higher resolution around

628
00:25:40,630 --> 00:25:38,880
three tenths of a micron or less but it

629
00:25:43,590 --> 00:25:40,640
measures fluorescence not chemical

630
00:25:46,149 --> 00:25:43,600
structures it does not identify minerals

631
00:25:48,310 --> 00:25:46,159
and it really only at this point uh

632
00:25:50,950 --> 00:25:48,320
suggests and something went off the

633
00:25:55,029 --> 00:25:50,960
screen there right before my eyes uh

634
00:25:56,950 --> 00:25:55,039
suggests uh organic geochemical maturity

635
00:25:59,669 --> 00:25:56,960
and i don't know what's going on here

636
00:26:01,110 --> 00:25:59,679
but uh we're i hope you're seeing this

637
00:26:03,110 --> 00:26:01,120
uh

638
00:26:06,230 --> 00:26:03,120

ramen on the other hand has lower

639
00:26:08,470 --> 00:26:06,240
resolution about uh nine tenths of a no

640
00:26:11,510 --> 00:26:08,480
it's still sub micron and it can

641
00:26:14,149 --> 00:26:11,520
identify minerals used commonly for that

642
00:26:15,750 --> 00:26:14,159
purpose as well as carbonaceous material

643
00:26:18,149 --> 00:26:15,760
and it can it can

644
00:26:19,269 --> 00:26:18,159
characterize geochemical maturity

645
00:26:21,430 --> 00:26:19,279
okay

646
00:26:25,510 --> 00:26:21,440
now with that introduction as

647
00:26:30,710 --> 00:26:28,149
i'm going to show you three examples of

648
00:26:32,070 --> 00:26:30,720
uh recent work we've done uh

649
00:26:35,029 --> 00:26:32,080
illustrating

650
00:26:38,470 --> 00:26:35,039
uh the use of these techniques one i

651
00:26:41,190 --> 00:26:38,480
want to show you the oldest uh

652
00:26:42,630 --> 00:26:41,200
the oldest tenefore that is comb jelly

653
00:26:45,830 --> 00:26:42,640
uh ambrya

654
00:26:49,029 --> 00:26:45,840
animal embryo that's ever been found 540

655
00:26:50,470 --> 00:26:49,039
million years in age uh from china uh

656
00:26:53,029 --> 00:26:50,480
then i want to show you a little study

657
00:26:55,590 --> 00:26:53,039
with that's currently impressed uh

658
00:26:57,909 --> 00:26:55,600
looking for pre-cambrian micro microbes

659
00:27:00,710 --> 00:26:57,919
in the foothills of the himalayas

660
00:27:03,269 --> 00:27:00,720
uh believe it or not and uh something

661
00:27:06,310 --> 00:27:03,279
about the oldest hints of life on the

662
00:27:09,269 --> 00:27:06,320
planet uh all three of these we've used

663
00:27:13,269 --> 00:27:09,279

those techniques on okay well this uh

664
00:27:16,549 --> 00:27:13,279
microscopic uh uh animal uh embryo is

665
00:27:17,350 --> 00:27:16,559
published in 2007 and pnas

666
00:27:21,510 --> 00:27:17,360
uh

667
00:27:23,990 --> 00:27:21,520
province of china

668
00:27:27,830 --> 00:27:24,000
it's around 540 million years in age

669
00:27:30,070 --> 00:27:27,840
it's right at the base of the cambrian

670
00:27:32,549 --> 00:27:30,080
just exactly at the base of the cambrian

671
00:27:34,630 --> 00:27:32,559
within a couple million years

672
00:27:36,549 --> 00:27:34,640
and here for those who haven't seen a

673
00:27:40,630 --> 00:27:36,559
comb jelly for a while

674
00:27:44,470 --> 00:27:40,640
uh those uh lines were at one point

675
00:27:47,110 --> 00:27:44,480
pointing to eight rows eight comb rows

676
00:27:49,110 --> 00:27:47,120
but you can count them and it's a nice

677
00:27:51,909 --> 00:27:49,120
photograph so you can see them

678
00:27:55,029 --> 00:27:51,919
comb jellies are usually thought to be

679
00:27:58,070 --> 00:27:55,039
related to jellyfish

680
00:28:00,470 --> 00:27:58,080
they're voracious predators they live

681
00:28:01,990 --> 00:28:00,480
rather deep in the oceans and they eat

682
00:28:04,710 --> 00:28:02,000
anything they get their hands on they're

683
00:28:06,710 --> 00:28:04,720
kind of nasty guys but they originated

684
00:28:10,149 --> 00:28:06,720
during the cambrian explosion

685
00:28:14,950 --> 00:28:10,159
um and here on the left is an optical

686
00:28:17,029 --> 00:28:14,960
image of uh this comb jelly um embryo

687
00:28:19,830 --> 00:28:17,039
it's in late stage just prior to

688
00:28:23,269 --> 00:28:19,840

hatching and on the right is a clsm

689
00:28:26,230 --> 00:28:23,279
image of it uh and there the parts of it

690
00:28:28,470 --> 00:28:26,240
are identified the apical organ is a

691
00:28:31,190 --> 00:28:28,480
sense organ the meridian canals you can

692
00:28:32,230 --> 00:28:31,200
think of as a kind of an early vascular

693
00:28:35,269 --> 00:28:32,240
system

694
00:28:38,070 --> 00:28:35,279
um the ab oral canal is

695
00:28:39,990 --> 00:28:38,080
kind of a proto gut if you will and the

696
00:28:42,950 --> 00:28:40,000
egg membrane you can see at the edge of

697
00:28:46,070 --> 00:28:42,960
it and the identifying feature are these

698
00:28:49,110 --> 00:28:46,080
teams uh particularly evident they're on

699
00:28:52,549 --> 00:28:49,120
the left of the right of the optical

700
00:28:54,710 --> 00:28:52,559
image and the right of the clsm image

701
00:28:57,029 --> 00:28:54,720
okay well

702
00:28:59,669 --> 00:28:57,039
this one we're going to try to rotate uh

703
00:29:01,750 --> 00:28:59,679
this is a clsm image

704
00:29:05,350 --> 00:29:01,760
and marco is going to

705
00:29:06,710 --> 00:29:05,360
do his magic on this and show you

706
00:29:09,269 --> 00:29:06,720
uh

707
00:29:10,830 --> 00:29:09,279
some rather nice tricks with it it is in

708
00:29:12,549 --> 00:29:10,840
a very thin thin

709
00:29:15,350 --> 00:29:12,559
section uh

710
00:29:16,470 --> 00:29:15,360
that should have been no we no comb

711
00:29:18,230 --> 00:29:16,480
jelly we've

712
00:29:21,190 --> 00:29:18,240
skipped those other two

713
00:29:22,789 --> 00:29:21,200

to save time so we're on the last one

714
00:29:24,789 --> 00:29:22,799
the sixth one

715
00:29:26,470 --> 00:29:24,799
uh marco thank you

716
00:29:28,549 --> 00:29:26,480
i'm

717
00:29:29,990 --> 00:29:28,559
uh you can see it on my screen if you

718
00:29:31,830 --> 00:29:30,000
can see my screen but i don't know if

719
00:29:32,950 --> 00:29:31,840
you can see my screen there is something

720
00:29:36,230 --> 00:29:32,960
on my

721
00:29:37,990 --> 00:29:36,240
and mine is going uh is rotating nicely

722
00:29:40,789 --> 00:29:38,000
it's a thin thin section

723
00:29:43,110 --> 00:29:40,799
about 30 35 microns in

724
00:29:44,149 --> 00:29:43,120
thickness and that's a sort of standard

725
00:29:45,590 --> 00:29:44,159
thickness

726
00:29:48,389 --> 00:29:45,600
for

727
00:29:51,190 --> 00:29:48,399
such sections

728
00:29:52,630 --> 00:29:51,200
i personally prefer thicker sections

729
00:29:54,789 --> 00:29:52,640
because you can see

730
00:29:57,430 --> 00:29:54,799
a good deal more

731
00:30:00,549 --> 00:29:57,440
of the sorts of things i study in them

732
00:30:03,430 --> 00:30:00,559
uh and we've used ramen down to 160

733
00:30:07,909 --> 00:30:03,440
microns in thick in sections and and

734
00:30:10,230 --> 00:30:07,919
clsm uh down to about 190 microns and

735
00:30:13,430 --> 00:30:10,240
so we can handle any

736
00:30:15,750 --> 00:30:13,440
uh standard petrographic uh preparation

737
00:30:18,389 --> 00:30:15,760
without any problem at all

738
00:30:23,909 --> 00:30:18,399

okay let me go back to full screen again

739
00:30:29,190 --> 00:30:27,110
control enter an alternate

740
00:30:31,029 --> 00:30:29,200
okay okay

741
00:30:37,430 --> 00:30:31,039
and

742
00:30:41,029 --> 00:30:37,440
we are going to do something to make

743
00:30:44,470 --> 00:30:42,230
anyway

744
00:30:45,590 --> 00:30:44,480
now you can advance with it

745
00:30:49,190 --> 00:30:45,600
okay

746
00:30:52,630 --> 00:30:49,200
all right well here you can see um in uh

747
00:30:54,470 --> 00:30:52,640
two clsm images the eight co embryonic

748
00:30:57,110 --> 00:30:54,480
comrose that define

749
00:31:00,630 --> 00:30:57,120
uh the phylogeny of that particular

750
00:31:03,430 --> 00:31:00,640
organism uh it turns out that uh adult

751
00:31:06,230 --> 00:31:03,440
tener fours are known about 10 million

752
00:31:08,870 --> 00:31:06,240
years younger than this uh but this is

753
00:31:10,710 --> 00:31:08,880
the first and only um

754
00:31:12,870 --> 00:31:10,720
comb jelly embryo that's ever been found

755
00:31:16,710 --> 00:31:12,880
and it is right at the cambrian boundary

756
00:31:19,269 --> 00:31:16,720
uh we also wanted to uh now use ramen to

757
00:31:22,470 --> 00:31:19,279
figure out how it was preserved

758
00:31:25,430 --> 00:31:22,480
and here is a ramen spectrum a spectra

759
00:31:27,830 --> 00:31:25,440
of the three mineral phases

760
00:31:31,590 --> 00:31:27,840
in which this thing is preserved it's

761
00:31:34,470 --> 00:31:31,600
largely preserved in appetite

762
00:31:37,350 --> 00:31:34,480
with secondary infilling of calcite but

763
00:31:39,990 --> 00:31:37,360

you can see the spectra there uh here is

764
00:31:42,070 --> 00:31:40,000
the optical image now in the lower

765
00:31:45,509 --> 00:31:42,080
left-hand quadrant

766
00:31:46,389 --> 00:31:45,519
uh a clsm image a portion of which i'll

767
00:31:47,509 --> 00:31:46,399
show you

768
00:31:49,269 --> 00:31:47,519
first

769
00:31:51,110 --> 00:31:49,279
in the carriage and image now what we've

770
00:31:52,710 --> 00:31:51,120
done here is use the carriage and window

771
00:31:55,029 --> 00:31:52,720
colored it blue

772
00:31:57,430 --> 00:31:55,039
and everything in that window that is

773
00:31:59,430 --> 00:31:57,440
blue is kerogen and so you can see that

774
00:32:02,549 --> 00:31:59,440
the soft tissues

775
00:32:05,350 --> 00:32:02,559
are composed of this organic material

776
00:32:09,350 --> 00:32:05,360
ah but now we switch uh in the raman

777
00:32:13,830 --> 00:32:09,360
image to uh phosphate to appetite

778
00:32:15,909 --> 00:32:13,840
and uh the appetite you see is infusing

779
00:32:18,710 --> 00:32:15,919
uh or per mineralizing

780
00:32:19,990 --> 00:32:18,720
uh the uh kerogen of the organic

781
00:32:22,310 --> 00:32:20,000
material so that's where it was

782
00:32:26,470 --> 00:32:22,320
originally preserved and the image on

783
00:32:29,990 --> 00:32:26,480
the right which uh is there the green

784
00:32:32,950 --> 00:32:30,000
is calcite and the calcite has infilled

785
00:32:35,269 --> 00:32:32,960
open spaces the vascular system

786
00:32:39,350 --> 00:32:35,279
uh in it and open spaces between the

787
00:32:42,070 --> 00:32:39,360
embryo and the uh egg membrane so uh by

788
00:32:46,149 --> 00:32:42,080

using these two techniques we can not

789
00:32:48,389 --> 00:32:46,159
only uh look at the the uh morphology of

790
00:32:51,350 --> 00:32:48,399
the fossil figure out what it is and how

791
00:32:54,470 --> 00:32:51,360
it and so forth but using ramen we can

792
00:32:56,789 --> 00:32:54,480
figure out its uh taphonomy that is this

793
00:32:59,029 --> 00:32:56,799
the series of events that have caused it

794
00:33:01,269 --> 00:32:59,039
to be preserved

795
00:33:05,590 --> 00:33:01,279
well i do not claim folks that we're

796
00:33:08,070 --> 00:33:05,600
going to find tenefore larvae on mars

797
00:33:10,070 --> 00:33:08,080
ah i just wanted to show you that one

798
00:33:11,590 --> 00:33:10,080
because it's interesting and what you

799
00:33:13,830 --> 00:33:11,600
can do about trying to figure out how

800
00:33:15,909 --> 00:33:13,840
these things are preserved but this

801
00:33:18,230 --> 00:33:15,919
little second study which is currently

802
00:33:20,230 --> 00:33:18,240
impressed in astrobiology is a little

803
00:33:24,230 --> 00:33:20,240
bit more relevant or is more relevant i

804
00:33:26,310 --> 00:33:24,240
think uh to the search for life on mars

805
00:33:29,990 --> 00:33:26,320
and uh

806
00:33:31,190 --> 00:33:30,000
the problem with uh mars sample return

807
00:33:34,630 --> 00:33:31,200
of course

808
00:33:36,950 --> 00:33:34,640
uh as you all know is that uh for the

809
00:33:38,549 --> 00:33:36,960
first several missions the payload that

810
00:33:40,630 --> 00:33:38,559
we're going to get back

811
00:33:43,509 --> 00:33:40,640
uh is going to be low on the order of

812
00:33:45,669 --> 00:33:43,519
100 grams or less based on the weight

813
00:33:47,590 --> 00:33:45,679

that you can lift off the martian

814
00:33:50,950 --> 00:33:47,600
surface and bring home

815
00:33:52,070 --> 00:33:50,960
and probably that the organic the rocks

816
00:33:53,350 --> 00:33:52,080
that we're going to get are going to be

817
00:33:55,669 --> 00:33:53,360
fairly old

818
00:33:58,710 --> 00:33:55,679
uh or maybe very old

819
00:34:00,950 --> 00:33:58,720
and perhaps highly altered by the light

820
00:34:03,430 --> 00:34:00,960
impacts and things of this sort

821
00:34:06,870 --> 00:34:03,440
uh at the bottom of

822
00:34:10,790 --> 00:34:06,880
this you can see a nice nasa current uh

823
00:34:12,550 --> 00:34:10,800
reconstruction or pre-construction of uh

824
00:34:13,829 --> 00:34:12,560
how we might get such samples be

825
00:34:15,030 --> 00:34:13,839
returned

826
00:34:17,030 --> 00:34:15,040
well

827
00:34:19,669 --> 00:34:17,040
this brings up the question about what

828
00:34:22,710 --> 00:34:19,679
amount of rock is going to be needed

829
00:34:23,750 --> 00:34:22,720
to establish the existence of ancient

830
00:34:26,230 --> 00:34:23,760
life

831
00:34:28,470 --> 00:34:26,240
i want to point out that that problem

832
00:34:29,430 --> 00:34:28,480
has two components

833
00:34:31,349 --> 00:34:29,440
one

834
00:34:32,710 --> 00:34:31,359
how much rot

835
00:34:34,550 --> 00:34:32,720
and two

836
00:34:36,470 --> 00:34:34,560
how do you show that that's truly

837
00:34:37,829 --> 00:34:36,480
biological

838
00:34:38,950 --> 00:34:37,839

and those are the questions i want to

839
00:34:45,349 --> 00:34:38,960
address

840
00:34:47,109 --> 00:34:45,359
just a beginning preliminary study of

841
00:34:50,310 --> 00:34:47,119
this problem

842
00:34:51,589 --> 00:34:50,320
uh up in northeastern

843
00:34:53,750 --> 00:34:51,599
india

844
00:34:56,310 --> 00:34:53,760
in the foothill hills or the high

845
00:34:59,990 --> 00:34:56,320
foothills of the himalayas

846
00:35:01,109 --> 00:35:00,000
uh the lesser himalayas there in sikkim

847
00:35:03,750 --> 00:35:01,119
uh

848
00:35:05,829 --> 00:35:03,760
i had an an indian colleague here

849
00:35:07,829 --> 00:35:05,839
uh vinod tawari

850
00:35:11,109 --> 00:35:07,839
uh and he'd done a good deal field work

851
00:35:12,550 --> 00:35:11,119
up there uh in a section that has been

852
00:35:14,630 --> 00:35:12,560
measured that had carbonate

853
00:35:16,950 --> 00:35:14,640
stromatolites in it or has carbonate

854
00:35:19,510 --> 00:35:16,960
stromatolites as you can see this is the

855
00:35:21,910 --> 00:35:19,520
box of formation and it's neoproterozoic

856
00:35:22,790 --> 00:35:21,920
it's around a billion years old

857
00:35:29,270 --> 00:35:22,800
uh

858
00:35:32,150 --> 00:35:29,280
the bottom of this section now fossils

859
00:35:35,589 --> 00:35:32,160
have never been reported from this area

860
00:35:37,670 --> 00:35:35,599
uh it's the range it tectonic window for

861
00:35:40,150 --> 00:35:37,680
the geologists out there

862
00:35:42,230 --> 00:35:40,160
uh never been found in there at all

863
00:35:45,430 --> 00:35:42,240

uh and it's pretty well chewed up

864
00:35:46,950 --> 00:35:45,440
because it is a a an area of active

865
00:35:48,069 --> 00:35:46,960
tectonism

866
00:35:50,310 --> 00:35:48,079
uh

867
00:35:51,990 --> 00:35:50,320
the carbonate stromatolites we were not

868
00:35:54,310 --> 00:35:52,000
collected because carbonate

869
00:35:56,870 --> 00:35:54,320
stromatolites do not have microscopic

870
00:35:59,670 --> 00:35:56,880
fossils in them uh what happens when the

871
00:36:01,910 --> 00:35:59,680
carbonate grains

872
00:36:04,870 --> 00:36:01,920
grow and the grains in the sediments

873
00:36:07,430 --> 00:36:04,880
start to grow they expand and they crush

874
00:36:09,270 --> 00:36:07,440
at their grain boundaries uh the

875
00:36:11,349 --> 00:36:09,280
microorganisms that were originally

876
00:36:13,270 --> 00:36:11,359
present in such termatolites

877
00:36:15,589 --> 00:36:13,280
so you just get a residuum of

878
00:36:18,150 --> 00:36:15,599
carbonaceous matter derived from the

879
00:36:20,230 --> 00:36:18,160
bacteria that were originally there

880
00:36:22,630 --> 00:36:20,240
but there's no morphology

881
00:36:25,589 --> 00:36:22,640
uh we collected bedded shirts because

882
00:36:27,670 --> 00:36:25,599
church sometimes contain fossils but

883
00:36:30,470 --> 00:36:27,680
folks almost know

884
00:36:32,550 --> 00:36:30,480
it's very it's rare to find microscopic

885
00:36:34,630 --> 00:36:32,560
fossils in shirts most of them don't

886
00:36:38,069 --> 00:36:34,640
contain fossils

887
00:36:39,910 --> 00:36:38,079
but anyway that was the thing to collect

888
00:36:42,310 --> 00:36:39,920

and it's a fairly good test because this

889
00:36:44,150 --> 00:36:42,320
is a tectonically active metamorphosed

890
00:36:46,470 --> 00:36:44,160
regions we didn't collect stromatolites

891
00:36:48,630 --> 00:36:46,480
and no microfossils had ever been found

892
00:36:50,230 --> 00:36:48,640
well we only had these two little thin

893
00:36:53,589 --> 00:36:50,240
sections of rock

894
00:36:55,990 --> 00:36:53,599
that's all we had uh and the question

895
00:36:57,510 --> 00:36:56,000
was given that can you show whether

896
00:36:59,990 --> 00:36:57,520
there's life there

897
00:37:02,470 --> 00:37:00,000
uh show you how small these things are

898
00:37:05,670 --> 00:37:02,480
uh their total area is about five square

899
00:37:08,710 --> 00:37:05,680
centimeters which is less than

900
00:37:10,390 --> 00:37:08,720
less than the size of a u.s postage

901
00:37:14,230 --> 00:37:10,400
stamp

902
00:37:16,950 --> 00:37:14,240
uh in terms of the volume

903
00:37:18,870 --> 00:37:16,960
the volume is around four hundredths of

904
00:37:21,670 --> 00:37:18,880
a cubic centimeter which is

905
00:37:24,790 --> 00:37:21,680
approximately or less than

906
00:37:26,790 --> 00:37:24,800
half a grain of rice

907
00:37:30,550 --> 00:37:26,800
since you know the volume

908
00:37:32,310 --> 00:37:30,560
and since you know the density of quartz

909
00:37:34,069 --> 00:37:32,320
or silica which these rocks are

910
00:37:36,710 --> 00:37:34,079
predominantly made of

911
00:37:37,910 --> 00:37:36,720
which is 2.6 grams per cubic

912
00:37:41,109 --> 00:37:37,920
centimeter

913
00:37:43,589 --> 00:37:41,119

the rock weight is approximately one

914
00:37:48,790 --> 00:37:43,599
tenth of one gram

915
00:37:50,550 --> 00:37:48,800
can you show that there was life there a

916
00:37:53,109 --> 00:37:50,560
billion years ago

917
00:37:55,670 --> 00:37:53,119
that had never been found before well

918
00:37:57,670 --> 00:37:55,680
uh here's a better church uh in the

919
00:38:00,630 --> 00:37:57,680
answer of course yes there are fossils

920
00:38:03,670 --> 00:38:00,640
in there uh they occur in fossil forest

921
00:38:06,150 --> 00:38:03,680
clasts these are rounded ripped up

922
00:38:09,430 --> 00:38:06,160
portions of stromatolites that

923
00:38:11,589 --> 00:38:09,440
got redeposited embedded shirts and then

924
00:38:12,390 --> 00:38:11,599
solidified

925
00:38:13,670 --> 00:38:12,400
the

926
00:38:16,470 --> 00:38:13,680
fossils

927
00:38:19,589 --> 00:38:16,480
range from being completely absent to

928
00:38:20,870 --> 00:38:19,599
maybe one to two uh fossils per square

929
00:38:23,910 --> 00:38:20,880
millimeter

930
00:38:26,310 --> 00:38:23,920
uh to maybe tens to maybe a hundred per

931
00:38:27,910 --> 00:38:26,320
square millimeter and in some places

932
00:38:30,310 --> 00:38:27,920
there might be several hundred per

933
00:38:33,589 --> 00:38:30,320
square millimeter uh but see that's

934
00:38:35,349 --> 00:38:33,599
characteristic of life life is patchy uh

935
00:38:38,150 --> 00:38:35,359
in these sorts of communities it's not

936
00:38:40,870 --> 00:38:38,160
homogeneous uh it's patchy one place to

937
00:38:43,190 --> 00:38:40,880
another and one class to another and one

938
00:38:45,430 --> 00:38:43,200

part of one class to another

939
00:38:48,390 --> 00:38:45,440
uh that's rather typical for micro

940
00:38:51,349 --> 00:38:48,400
microbes in general well how do you how

941
00:38:53,910 --> 00:38:51,359
do you establish that they're biological

942
00:38:55,589 --> 00:38:53,920
there is no smoking gun there is no

943
00:38:58,870 --> 00:38:55,599
silver bullet

944
00:39:01,670 --> 00:38:58,880
the fact is that one it's a cascade of

945
00:39:03,750 --> 00:39:01,680
evidence is what is required a whole set

946
00:39:06,470 --> 00:39:03,760
of interrelated questions and the and

947
00:39:08,950 --> 00:39:06,480
the the the way to approach it is if

948
00:39:11,030 --> 00:39:08,960
this is true then this must be true if

949
00:39:13,030 --> 00:39:11,040
that is true then this must be true if

950
00:39:15,910 --> 00:39:13,040
that is true then this must be true a

951
00:39:17,750 --> 00:39:15,920
whole cascade of these things uh that

952
00:39:19,829 --> 00:39:17,760
are put together that'll give you some

953
00:39:22,310 --> 00:39:19,839
confidence that you're really gonna deal

954
00:39:23,829 --> 00:39:22,320
with something that was once alive so

955
00:39:25,910 --> 00:39:23,839
you ask about the preservational

956
00:39:28,069 --> 00:39:25,920
environment is it biologically possible

957
00:39:29,910 --> 00:39:28,079
are there other examples because one of

958
00:39:32,150 --> 00:39:29,920
a kinds are suspect

959
00:39:33,670 --> 00:39:32,160
well turns out yeah there are a bunch of

960
00:39:35,270 --> 00:39:33,680
other examples like this what about

961
00:39:37,589 --> 00:39:35,280
biological morphology are they

962
00:39:40,390 --> 00:39:37,599
bacterium-like in form do they have

963
00:39:42,550 --> 00:39:40,400

biological size ranges do they occur in

964
00:39:44,550 --> 00:39:42,560
biological populations

965
00:39:46,630 --> 00:39:44,560
anytime that somebody comes up with one

966
00:39:47,829 --> 00:39:46,640
single fossil and tells you that's

967
00:39:50,950 --> 00:39:47,839
evidence of life you ought to be

968
00:39:52,550 --> 00:39:50,960
skeptical life is communal uh you the

969
00:39:55,270 --> 00:39:52,560
only place you're ever going to find a

970
00:39:57,589 --> 00:39:55,280
monospecific assemblage of microbes is

971
00:40:00,630 --> 00:39:57,599
in a microbiology lab

972
00:40:02,470 --> 00:40:00,640
uh life is made these are communities of

973
00:40:04,550 --> 00:40:02,480
organisms so if one guy can get

974
00:40:06,710 --> 00:40:04,560
preserved other ones should be

975
00:40:08,390 --> 00:40:06,720
preservable you ought to find lots of

976
00:40:10,150 --> 00:40:08,400
examples of the same things and they

977
00:40:11,670 --> 00:40:10,160
ought to be lots of different types of

978
00:40:13,829 --> 00:40:11,680
things there

979
00:40:15,670 --> 00:40:13,839
and what about biological chemistry or

980
00:40:17,589 --> 00:40:15,680
geochemically altered biological

981
00:40:19,109 --> 00:40:17,599
chemistry they ought to be made out of

982
00:40:21,190 --> 00:40:19,119
that if they're preserved in this way

983
00:40:22,950 --> 00:40:21,200
are they carbonaceous and are they like

984
00:40:25,030 --> 00:40:22,960
other fossils because life is

985
00:40:27,430 --> 00:40:25,040
carbon-based well that gives you a

986
00:40:30,870 --> 00:40:27,440
beginning of the list that you have to

987
00:40:33,270 --> 00:40:30,880
to approach uh the three major uh

988
00:40:34,710 --> 00:40:33,280

aspects are do they have biological

989
00:40:36,950 --> 00:40:34,720
morphology

990
00:40:38,950 --> 00:40:36,960
uh do they have geochemically altered

991
00:40:41,829 --> 00:40:38,960
biological chemistry and their

992
00:40:44,310 --> 00:40:41,839
geochemical maturity and that third

993
00:40:45,750 --> 00:40:44,320
aspect is extremely important because

994
00:40:47,670 --> 00:40:45,760
that tells you whether they really

995
00:40:49,589 --> 00:40:47,680
belong in the rock or not

996
00:40:51,910 --> 00:40:49,599
so you won't get fooled by modern

997
00:40:54,310 --> 00:40:51,920
contaminants or endolyths that have

998
00:40:56,710 --> 00:40:54,320
bored into a rock at some later time and

999
00:41:00,230 --> 00:40:56,720
ramen can tell you that answer too

1000
00:41:02,710 --> 00:41:00,240
so biological morphology well as you can

1001
00:41:04,710 --> 00:41:02,720
see they're sinuous uh

1002
00:41:08,069 --> 00:41:04,720
the the filament in the middle is

1003
00:41:09,910 --> 00:41:08,079
tubular these two top things are

1004
00:41:11,910 --> 00:41:09,920
the extracellular sheaths of

1005
00:41:13,589 --> 00:41:11,920
cyanobacteria

1006
00:41:16,790 --> 00:41:13,599
down at the bottom

1007
00:41:18,390 --> 00:41:16,800
is a cyanobacterial filament and i just

1008
00:41:20,950 --> 00:41:18,400
clicked it there was supposed to be a

1009
00:41:23,510 --> 00:41:20,960
whole bunch of arrows coming up

1010
00:41:25,670 --> 00:41:23,520
to denote the cells but you can see the

1011
00:41:27,910 --> 00:41:25,680
cells you don't need me to denote them

1012
00:41:30,550 --> 00:41:27,920
you can see the cell walls and the cell

1013
00:41:32,470 --> 00:41:30,560

lumina in between the cell walls where

1014
00:41:34,790 --> 00:41:32,480
the cell juices are

1015
00:41:37,190 --> 00:41:34,800
okay so they certainly have biological

1016
00:41:38,950 --> 00:41:37,200
morphology uh what about are they

1017
00:41:41,030 --> 00:41:38,960
three-dimensional are they composed of

1018
00:41:43,670 --> 00:41:41,040
organic matter well uh you do

1019
00:41:46,390 --> 00:41:43,680
two-dimensional raman imagery as shown

1020
00:41:49,430 --> 00:41:46,400
here at the bottom left of that uh

1021
00:41:51,430 --> 00:41:49,440
rectangle in the middle of in red and

1022
00:41:53,589 --> 00:41:51,440
yes the stuff that lights up in white

1023
00:41:55,750 --> 00:41:53,599
that's kerogen uh we've got the carriage

1024
00:41:56,870 --> 00:41:55,760
and spectrum of it so yes either made of

1025
00:41:59,109 --> 00:41:56,880
kerogen

1026
00:42:02,790 --> 00:41:59,119
are they three-dimensional even in rocks

1027
00:42:06,309 --> 00:42:02,800
this chewed up this metamorphosed um

1028
00:42:08,230 --> 00:42:06,319
this is a cls m image from underneath

1029
00:42:11,109 --> 00:42:08,240
the the thin section which you can't do

1030
00:42:13,109 --> 00:42:11,119
by any other technique uh and turns out

1031
00:42:15,109 --> 00:42:13,119
yes they are three-dimensional just as

1032
00:42:17,750 --> 00:42:15,119
they should be and you can show it and

1033
00:42:19,990 --> 00:42:17,760
there are many specimens there are many

1034
00:42:22,470 --> 00:42:20,000
species they vary in size some are

1035
00:42:23,910 --> 00:42:22,480
colonial some are single-celled uh

1036
00:42:25,589 --> 00:42:23,920
there's a nice colony there in the

1037
00:42:27,829 --> 00:42:25,599
middle row and the upper and the bottom

1038
00:42:29,589 --> 00:42:27,839

and the middle left uh and there's some

1039
00:42:30,710 --> 00:42:29,599
large sphere steroids down at the right

1040
00:42:32,790 --> 00:42:30,720
these are

1041
00:42:36,710 --> 00:42:32,800
typical of what one finds in

1042
00:42:38,550 --> 00:42:36,720
billion-year-old microfossil assemblages

1043
00:42:40,309 --> 00:42:38,560
okay well they meet all those tests what

1044
00:42:43,670 --> 00:42:40,319
about their chemistry

1045
00:42:44,710 --> 00:42:43,680
and what i've done here is to stack

1046
00:42:48,470 --> 00:42:44,720
in the

1047
00:42:50,790 --> 00:42:48,480
spectra uh taken from six different

1048
00:42:54,790 --> 00:42:50,800
geologic units

1049
00:42:57,109 --> 00:42:54,800
uh spectra taken of authentic bona fide

1050
00:42:59,510 --> 00:42:57,119
microscopic fossils

1051
00:43:02,550 --> 00:42:59,520
that have been preserved to varying

1052
00:43:04,550 --> 00:43:02,560
degrees the ones at the top are well

1053
00:43:06,870 --> 00:43:04,560
preserved the ones at the bottom are

1054
00:43:09,190 --> 00:43:06,880
much less well preserved or more

1055
00:43:11,270 --> 00:43:09,200
graphitized as you can see the

1056
00:43:15,829 --> 00:43:11,280
bifurcated uh

1057
00:43:18,390 --> 00:43:15,839
g-ban uh there are around 1500 uh

1058
00:43:20,309 --> 00:43:18,400
receptacle centimeters uh and they're

1059
00:43:22,309 --> 00:43:20,319
ordered by a

1060
00:43:24,950 --> 00:43:22,319
system called the raman index of

1061
00:43:27,510 --> 00:43:24,960
preservation that we've worked out to

1062
00:43:30,870 --> 00:43:27,520
categorize such spectra so that we can

1063
00:43:32,950 --> 00:43:30,880

uh categorize quantitatively uh the

1064
00:43:35,510 --> 00:43:32,960
geochemical maturity the material we

1065
00:43:37,270 --> 00:43:35,520
looked at well uh the box of formation

1066
00:43:39,589 --> 00:43:37,280
organic matter is right in the middle

1067
00:43:42,150 --> 00:43:39,599
just like more or less for the apex

1068
00:43:44,550 --> 00:43:42,160
organic matter fits it's a metamorphosed

1069
00:43:46,630 --> 00:43:44,560
but it's not metamorphosed as much as

1070
00:43:49,190 --> 00:43:46,640
those down at the bottom

1071
00:43:51,190 --> 00:43:49,200
well what about the age of these other

1072
00:43:53,510 --> 00:43:51,200
fossils uh we don't know the age of the

1073
00:43:56,470 --> 00:43:53,520
buxom very well it's neoproterozoic

1074
00:43:58,870 --> 00:43:56,480
around a billion years in age uh all

1075
00:44:02,630 --> 00:43:58,880
three of those uh at the top bitter

1076
00:44:07,589 --> 00:44:02,640
springs by luchten and alamor uh from uh

1077
00:44:10,790 --> 00:44:07,599
australia uh uh siberia and uh texas are

1078
00:44:13,270 --> 00:44:10,800
all uh about the same age and down here

1079
00:44:15,589 --> 00:44:13,280
uh the skill galley and the

1080
00:44:17,829 --> 00:44:15,599
auburn dolomite in the river wakefield

1081
00:44:21,030 --> 00:44:17,839
they're all about the same age and the

1082
00:44:25,030 --> 00:44:21,040
fact is that uh maturity is not a

1083
00:44:27,190 --> 00:44:25,040
function of geological age maturity is a

1084
00:44:30,150 --> 00:44:27,200
function of the local geologic

1085
00:44:32,710 --> 00:44:30,160
conditions uh those three uh the skill

1086
00:44:35,510 --> 00:44:32,720
of golly auburn and river wakefield at

1087
00:44:37,430 --> 00:44:35,520
the bottom uh the two bottom ones in

1088
00:44:39,910 --> 00:44:37,440

particular are from the peak and denison

1089
00:44:42,150 --> 00:44:39,920
ranges in south australia and that's a

1090
00:44:43,589 --> 00:44:42,160
really metamorphosed area

1091
00:44:45,589 --> 00:44:43,599
uh uh

1092
00:44:47,910 --> 00:44:45,599
more metamorph more

1093
00:44:51,430 --> 00:44:47,920
more metamorphosed than the bucks

1094
00:44:53,030 --> 00:44:51,440
in sikkim but a lot less metamorphosed

1095
00:44:54,870 --> 00:44:53,040
say than the bitter springs in central

1096
00:44:57,109 --> 00:44:54,880
australia at the top has to do with the

1097
00:44:59,270 --> 00:44:57,119
local geologic environment don't get it

1098
00:45:02,870 --> 00:44:59,280
confused with age

1099
00:45:04,790 --> 00:45:02,880
okay well are these things really in

1100
00:45:07,270 --> 00:45:04,800
the rock and what does ramen tell us

1101
00:45:09,430 --> 00:45:07,280
well those two arrows or lines that are

1102
00:45:12,550 --> 00:45:09,440
arrows are trying to get out there

1103
00:45:15,589 --> 00:45:12,560
were to point to two specific portions

1104
00:45:18,950 --> 00:45:15,599
of the filament um that and then those

1105
00:45:21,349 --> 00:45:18,960
are spectra from those portions and over

1106
00:45:24,150 --> 00:45:21,359
here well you can sort of make out that

1107
00:45:26,630 --> 00:45:24,160
those spectra come from globs of

1108
00:45:29,030 --> 00:45:26,640
particulate organic matter all these

1109
00:45:31,270 --> 00:45:29,040
rocks have lots of globs of organic

1110
00:45:34,550 --> 00:45:31,280
matter which is degraded bacterial

1111
00:45:36,550 --> 00:45:34,560
residueum and so forth and the test is

1112
00:45:38,230 --> 00:45:36,560
if all of that organic matter was

1113
00:45:40,230 --> 00:45:38,240

deposited at the same time it has had

1114
00:45:42,950 --> 00:45:40,240
the same geochemical history and

1115
00:45:46,630 --> 00:45:42,960
consequently i'll have the same

1116
00:45:47,990 --> 00:45:46,640
geochemical signal the same degree of

1117
00:45:50,230 --> 00:45:48,000
maturity

1118
00:45:53,109 --> 00:45:50,240
and so you can test this way on the

1119
00:45:55,589 --> 00:45:53,119
contrary if if the fossils were a lot

1120
00:45:57,750 --> 00:45:55,599
younger they would be less metamorphosed

1121
00:46:01,270 --> 00:45:57,760
and have a very different raman spectrum

1122
00:46:03,750 --> 00:46:01,280
so rama spectra spectra of these sorts

1123
00:46:05,990 --> 00:46:03,760
tells you maturity which helps you solve

1124
00:46:07,910 --> 00:46:06,000
the problem of whether the fossils are

1125
00:46:09,990 --> 00:46:07,920
indigenous whether they really belong

1126
00:46:12,069 --> 00:46:10,000
there whether they're contaminants

1127
00:46:14,790 --> 00:46:12,079
all right well in this little little

1128
00:46:16,550 --> 00:46:14,800
test there's certainly biological their

1129
00:46:18,390 --> 00:46:16,560
preservational environment makes sense

1130
00:46:20,630 --> 00:46:18,400
there are lots of other examples of this

1131
00:46:23,190 --> 00:46:20,640
sort of thing uh the they have

1132
00:46:27,030 --> 00:46:23,200
biological bacterial like morphology

1133
00:46:29,510 --> 00:46:27,040
biologic size ranges uh uh they

1134
00:46:32,790 --> 00:46:29,520
occur in in populations there are many

1135
00:46:34,550 --> 00:46:32,800
specimens many species uh they're uh

1136
00:46:36,870 --> 00:46:34,560
carbonaceous they're just like other

1137
00:46:38,550 --> 00:46:36,880
fossils that we already know then they

1138
00:46:41,190 --> 00:46:38,560

pass the morphology chemistry and

1139
00:46:44,150 --> 00:46:41,200
geochemical maturity test and the point

1140
00:46:47,349 --> 00:46:44,160
of this little exercise was simply to

1141
00:46:49,670 --> 00:46:47,359
see whether and the answer is yes even a

1142
00:46:51,750 --> 00:46:49,680
miniscule amount of rock if you have the

1143
00:46:54,470 --> 00:46:51,760
right amount of rock and the right rock

1144
00:46:57,109 --> 00:46:54,480
you're looking at uh can contain firm

1145
00:46:59,750 --> 00:46:57,119
remnants of life now i should hasten to

1146
00:47:02,390 --> 00:46:59,760
say that after we got this study done

1147
00:47:04,470 --> 00:47:02,400
we looked at three more bedded shirts up

1148
00:47:06,230 --> 00:47:04,480
section and we didn't find any fossils

1149
00:47:10,069 --> 00:47:06,240
in there there's organic matter but

1150
00:47:11,829 --> 00:47:10,079
nothing was preserved uh so uh the fact

1151
00:47:14,390 --> 00:47:11,839
is you've got to have the right rock to

1152
00:47:15,750 --> 00:47:14,400
look at but in this test we were able to

1153
00:47:18,150 --> 00:47:15,760
pass it

1154
00:47:20,230 --> 00:47:18,160
okay well there's the animal embryo at

1155
00:47:22,550 --> 00:47:20,240
the cambrian pre-cambrian boundary uh

1156
00:47:25,910 --> 00:47:22,560
fossils in tiny samples around a billion

1157
00:47:28,390 --> 00:47:25,920
years ago and now i want to go back to a

1158
00:47:31,510 --> 00:47:28,400
study that was just published this last

1159
00:47:32,630 --> 00:47:31,520
october uh the work we did on the

1160
00:47:36,390 --> 00:47:32,640
achillea

1161
00:47:38,390 --> 00:47:36,400
uh around 3.8 billion years in age from

1162
00:47:40,230 --> 00:47:38,400
southwestern greenland

1163
00:47:42,630 --> 00:47:40,240

uh published in as you can see the

1164
00:47:47,990 --> 00:47:42,640
reference there at the bottom 2000

1165
00:47:49,109 --> 00:47:48,000
geology 35 page 591 594

1166
00:47:51,670 --> 00:47:49,119
the

1167
00:47:55,349 --> 00:47:51,680
material comes from southwestern

1168
00:47:58,550 --> 00:47:55,359
greenland a photo there the basic

1169
00:48:01,109 --> 00:47:58,560
basic argument here based on a paper

1170
00:48:03,109 --> 00:48:01,119
that steve moyes at all published in

1171
00:48:06,069 --> 00:48:03,119
1996

1172
00:48:07,030 --> 00:48:06,079
uh in which they made the claim that

1173
00:48:11,109 --> 00:48:07,040
there were

1174
00:48:13,910 --> 00:48:11,119
graphite inclusions within appetite in

1175
00:48:16,309 --> 00:48:13,920
these highly metamorphosed rocks and

1176
00:48:19,670 --> 00:48:16,319
that those graphite inclusions had life

1177
00:48:22,069 --> 00:48:19,680
isotopic uh signature

1178
00:48:24,230 --> 00:48:22,079
and not only that that they were common

1179
00:48:25,670 --> 00:48:24,240
in such grains of appetite well those

1180
00:48:27,190 --> 00:48:25,680
are the claims that were made and this

1181
00:48:28,230 --> 00:48:27,200
was interpreted

1182
00:48:30,069 --> 00:48:28,240
as

1183
00:48:32,549 --> 00:48:30,079
perhaps indicating the presence of

1184
00:48:34,870 --> 00:48:32,559
biologic activity

1185
00:48:36,870 --> 00:48:34,880
then in 2005

1186
00:48:39,030 --> 00:48:36,880
a year and a half ago

1187
00:48:42,069 --> 00:48:39,040
lepland at all uh had a nice little

1188
00:48:45,349 --> 00:48:42,079

paper in geology uh in which they looked

1189
00:48:47,349 --> 00:48:45,359
at 31 grains from they looked at 190

1190
00:48:50,230 --> 00:48:47,359
grains but only 31 grains from this

1191
00:48:52,710 --> 00:48:50,240
particular rock that moy just said all

1192
00:48:54,950 --> 00:48:52,720
had studied and they said that the

1193
00:48:57,190 --> 00:48:54,960
graphite inclusions were absent that

1194
00:48:58,870 --> 00:48:57,200
there were no such graphite conclusions

1195
00:49:01,910 --> 00:48:58,880
they couldn't find them

1196
00:49:04,870 --> 00:49:01,920
and this cast appall on this work uh

1197
00:49:06,549 --> 00:49:04,880
there's a real question as to what the

1198
00:49:08,230 --> 00:49:06,559
answer was

1199
00:49:10,230 --> 00:49:08,240
well uh

1200
00:49:13,790 --> 00:49:10,240
kevin mckeegan here was fortunate enough

1201
00:49:16,870 --> 00:49:13,800
to get a a sample of sample

1202
00:49:18,790 --> 00:49:16,880
g91-26 from kevin mckeegan or from uh

1203
00:49:20,870 --> 00:49:18,800
steve voyages

1204
00:49:22,150 --> 00:49:20,880
and the answer is yes graphite is

1205
00:49:23,549 --> 00:49:22,160
present

1206
00:49:25,829 --> 00:49:23,559
and you can see the optical

1207
00:49:27,430 --> 00:49:25,839
photomicrographs above

1208
00:49:28,870 --> 00:49:27,440
showing the

1209
00:49:31,829 --> 00:49:28,880
graphite

1210
00:49:34,069 --> 00:49:31,839
on the far right enclosed by appetite

1211
00:49:36,230 --> 00:49:34,079
enclosed by courts

1212
00:49:39,510 --> 00:49:36,240
now i make that claim

1213
00:49:41,990 --> 00:49:39,520

and this is a very controversial sort of

1214
00:49:44,870 --> 00:49:42,000
a problem and so i better have something

1215
00:49:46,470 --> 00:49:44,880
to back up that claim and of course to

1216
00:49:49,270 --> 00:49:46,480
do i wouldn't do it

1217
00:49:52,230 --> 00:49:49,280
and here is uh some of the evidence

1218
00:49:55,270 --> 00:49:52,240
these are two-dimensional ramen images

1219
00:49:57,589 --> 00:49:55,280
of that particular appetite grain on the

1220
00:50:00,710 --> 00:49:57,599
left the white

1221
00:50:02,870 --> 00:50:00,720
that is in the quartz band of the ramen

1222
00:50:06,870 --> 00:50:02,880
showing that yes it's include enclosed

1223
00:50:09,430 --> 00:50:06,880
in quartz on the middle middle bottom

1224
00:50:12,950 --> 00:50:09,440
the white is appetite showing that the

1225
00:50:15,109 --> 00:50:12,960
grain is indeed appetite and that kind

1226
00:50:17,910 --> 00:50:15,119
of a speck on the

1227
00:50:20,069 --> 00:50:17,920
right is the graphite in the graphite

1228
00:50:22,390 --> 00:50:20,079
band showing it's made of graphite and

1229
00:50:24,309 --> 00:50:22,400
here are the spectra that uh support

1230
00:50:26,710 --> 00:50:24,319
that contention so you got two

1231
00:50:27,910 --> 00:50:26,720
dimensional mapping that in fact tells

1232
00:50:28,790 --> 00:50:27,920
you

1233
00:50:30,630 --> 00:50:28,800
that

1234
00:50:33,910 --> 00:50:30,640
the

1235
00:50:34,790 --> 00:50:33,920
distribution of those mineral phases

1236
00:50:36,950 --> 00:50:34,800
and

1237
00:50:38,390 --> 00:50:36,960
uh you've got raman that will give you

1238
00:50:40,470 --> 00:50:38,400

the raman spectrum that will show you

1239
00:50:42,309 --> 00:50:40,480
exactly what they are

1240
00:50:44,150 --> 00:50:42,319
okay

1241
00:50:47,030 --> 00:50:44,160
not only that

1242
00:50:48,470 --> 00:50:47,040
using three-dimensional ramen imagery as

1243
00:50:50,470 --> 00:50:48,480
i showed you earlier for one of the

1244
00:50:52,630 --> 00:50:50,480
microfossils you can do that on minerals

1245
00:50:56,230 --> 00:50:52,640
as well and this is an accurate

1246
00:50:57,430 --> 00:50:56,240
three-dimensional microscopic image

1247
00:51:00,230 --> 00:50:57,440
of

1248
00:51:03,190 --> 00:51:00,240
the graphite enclosed by appetite

1249
00:51:04,870 --> 00:51:03,200
enclosed by quartz

1250
00:51:06,710 --> 00:51:04,880
as far as i know no one else in the

1251
00:51:09,430 --> 00:51:06,720
world has been able to do this but we've

1252
00:51:11,510 --> 00:51:09,440
got a real good uh

1253
00:51:15,829 --> 00:51:11,520
expert on raman spectroscopy here

1254
00:51:17,910 --> 00:51:15,839
anatoly curiatza and a guy is a wizard

1255
00:51:19,109 --> 00:51:17,920
and this is really really nice as far as

1256
00:51:21,510 --> 00:51:19,119
i'm concerned

1257
00:51:24,630 --> 00:51:21,520
but what the advantage of it is

1258
00:51:26,069 --> 00:51:24,640
now that thing is supposed to undress

1259
00:51:29,109 --> 00:51:26,079
folks

1260
00:51:30,150 --> 00:51:29,119
i've never seen this not work well

1261
00:51:32,710 --> 00:51:30,160
if you

1262
00:51:35,750 --> 00:51:32,720
imagine this in your mind's eye

1263
00:51:38,230 --> 00:51:35,760

the pink comes off and it goes down to

1264
00:51:41,190 --> 00:51:38,240
the bottom and then the blue comes off

1265
00:51:42,470 --> 00:51:41,200
and it leaves this nice uh graphite

1266
00:51:44,710 --> 00:51:42,480
green in the middle and then it

1267
00:51:47,349 --> 00:51:44,720
re-clothes it and it comes down and it

1268
00:51:51,190 --> 00:51:47,359
re-clothes it and this one

1269
00:51:52,870 --> 00:51:51,200
if you could it rotates around uh

1270
00:51:56,230 --> 00:51:52,880
horizontally so that you can see the

1271
00:51:58,390 --> 00:51:56,240
tabular nature of the appetite grain

1272
00:51:59,270 --> 00:51:58,400
well uh it turns out those are really

1273
00:52:01,750 --> 00:51:59,280
nice

1274
00:52:04,470 --> 00:52:01,760
analytical tricks because

1275
00:52:06,870 --> 00:52:04,480
it does show the distribution that shows

1276
00:52:08,549 --> 00:52:06,880
there is graphite here and that is the

1277
00:52:11,750 --> 00:52:08,559
answer to the question is graphite

1278
00:52:14,630 --> 00:52:11,760
present shown by 3d raman imagery what

1279
00:52:17,589 --> 00:52:14,640
is the delta c13 well using the

1280
00:52:20,230 --> 00:52:17,599
secondary ion mass spectrometer uh the

1281
00:52:23,430 --> 00:52:20,240
sims uh facility in the second floor of

1282
00:52:25,710 --> 00:52:23,440
this building uh we showed we round down

1283
00:52:29,109 --> 00:52:25,720
to that graphite it showed that it was

1284
00:52:31,750 --> 00:52:29,119
-29 which is in the magic range usually

1285
00:52:33,430 --> 00:52:31,760
characteristic of biologic material is

1286
00:52:34,549 --> 00:52:33,440
this evidence of life well i certainly

1287
00:52:38,309 --> 00:52:34,559
don't know

1288
00:52:40,870 --> 00:52:38,319

i think it's a reasonable hint uh but it

1289
00:52:42,870 --> 00:52:40,880
uh it would satisfy me if there are a

1290
00:52:44,950 --> 00:52:42,880
whole lot more data and there are

1291
00:52:49,109 --> 00:52:44,960
supportive data for this i think

1292
00:52:51,670 --> 00:52:49,119
probably life was ex extent 3.8 billion

1293
00:52:54,309 --> 00:52:51,680
years ago but uh i don't know that for

1294
00:52:57,589 --> 00:52:54,319
sure i know it at 3.5 and i know it from

1295
00:53:00,069 --> 00:52:57,599
3.5 up to the present uh but i just

1296
00:53:02,230 --> 00:53:00,079
wanted you to see what rahman could do

1297
00:53:05,510 --> 00:53:02,240
with this problem so the take-home

1298
00:53:09,190 --> 00:53:05,520
lesson from this harangue of mine

1299
00:53:11,990 --> 00:53:09,200
about clsm and ramen is that both of

1300
00:53:13,510 --> 00:53:12,000
these techniques are accurate objective

1301
00:53:16,390 --> 00:53:13,520
they're non-destructive they're

1302
00:53:19,829 --> 00:53:16,400
non-intrusive they're three-dimensional

1303
00:53:23,270 --> 00:53:19,839
they do analyses inside to inside rocks

1304
00:53:25,750 --> 00:53:23,280
they work on keratinous fossils they do

1305
00:53:27,829 --> 00:53:25,760
mineralogy and petrology they'll tell

1306
00:53:30,630 --> 00:53:27,839
you about the morphology and the

1307
00:53:34,390 --> 00:53:30,640
taphonomy and the geochemistry and the

1308
00:53:35,349 --> 00:53:34,400
biogenicity of such objects and it seems

1309
00:53:38,150 --> 00:53:35,359
to me

1310
00:53:40,710 --> 00:53:38,160
that when we get those samples back from

1311
00:53:42,870 --> 00:53:40,720
mars these are prime techniques to use

1312
00:53:50,470 --> 00:53:42,880
to study them thanks very much for

1313
00:53:54,549 --> 00:53:52,390

bill thank you very much for a fabulous

1314
00:53:56,470 --> 00:53:54,559
talk and thanks to marco for helping

1315
00:53:57,990 --> 00:53:56,480
make all of the graphics work and thanks

1316
00:54:01,349 --> 00:53:58,000
to all of you who showed up this has

1317
00:54:03,829 --> 00:54:01,359
been a fabulous uh attendance for this

1318
00:54:06,309 --> 00:54:03,839
just before i open this up to questions

1319
00:54:08,710 --> 00:54:06,319
to bill and if you have a question

1320
00:54:11,109 --> 00:54:08,720
please raise your hand on webex

1321
00:54:13,510 --> 00:54:11,119
and we'll call on you i would like to

1322
00:54:15,829 --> 00:54:13,520
just put in a plug for the next two

1323
00:54:17,910 --> 00:54:15,839
director seminars we've got great

1324
00:54:21,430 --> 00:54:17,920
speakers coming up as well on monday

1325
00:54:23,030 --> 00:54:21,440
march 31st jim staley and jody deming of

1326
00:54:24,950 --> 00:54:23,040
the university of washington will be

1327
00:54:28,309 --> 00:54:24,960
talking about earth's low-temperature

1328
00:54:30,710 --> 00:54:28,319
life as an analog for mars and europa

1329
00:54:32,309 --> 00:54:30,720
and on april 28th steve benner of the

1330
00:54:33,910 --> 00:54:32,319
foundation for applied molecular

1331
00:54:35,829 --> 00:54:33,920
evolution is going to be talking about a

1332
00:54:37,910 --> 00:54:35,839
theory of life and that's going to be a

1333
00:54:40,630 --> 00:54:37,920
great talk as well the other thing i'd

1334
00:54:42,549 --> 00:54:40,640
like to just put in a plug for

1335
00:54:45,430 --> 00:54:42,559
are the archives of the director

1336
00:54:47,990 --> 00:54:45,440
seminars uh you can tell people who

1337
00:54:50,230 --> 00:54:48,000
weren't able to attend bill's talk today

1338
00:54:52,390 --> 00:54:50,240

that his talk will be up on our archives

1339
00:54:54,630 --> 00:54:52,400
which you can access from our website

1340
00:54:57,349 --> 00:54:54,640
within probably three or four days at

1341
00:55:00,390 --> 00:54:57,359
most and it will be almost as good as

1342
00:55:02,630 --> 00:55:00,400
being here with us today

1343
00:55:04,870 --> 00:55:02,640
so uh with that marco do we have any

1344
00:55:09,750 --> 00:55:04,880
hands raised on webex

1345
00:55:14,870 --> 00:55:11,750
hi bill this is dave diemera here at

1346
00:55:17,270 --> 00:55:14,880
ames uh that's the mike kubo hand

1347
00:55:19,430 --> 00:55:17,280
um i i want to ask a little bit about

1348
00:55:21,430 --> 00:55:19,440
the strategy for mars samples and that

1349
00:55:23,270 --> 00:55:21,440
is your points very well taken that if

1350
00:55:25,270 --> 00:55:23,280
you have the right piece of chart all

1351
00:55:27,190 --> 00:55:25,280
you need is a tenth of a gram or maybe

1352
00:55:29,670 --> 00:55:27,200
less but of course you raise the other

1353
00:55:31,430 --> 00:55:29,680
concern as getting the right piece

1354
00:55:34,470 --> 00:55:31,440
and so we're in the middle of trying to

1355
00:55:36,710 --> 00:55:34,480
consider sample return strategies and

1356
00:55:38,870 --> 00:55:36,720
we're trying we've sort of settled on 10

1357
00:55:40,950 --> 00:55:38,880
grams as the amount that we would take

1358
00:55:42,710 --> 00:55:40,960
for one sample

1359
00:55:44,950 --> 00:55:42,720
right here

1360
00:55:46,390 --> 00:55:44,960
and that's in part because of this

1361
00:55:47,589 --> 00:55:46,400
challenge that you mentioned that you

1362
00:55:49,750 --> 00:55:47,599
know how do you know you're going to

1363
00:55:51,670 --> 00:55:49,760

have the right piece so i wondered if

1364
00:55:54,230 --> 00:55:51,680
you could provide a little insight about

1365
00:55:56,870 --> 00:55:54,240
if you could actually pick a few grams

1366
00:55:59,109 --> 00:55:56,880
or maybe even several samples how you

1367
00:56:01,430 --> 00:55:59,119
would go about a sampling strategy or

1368
00:56:03,750 --> 00:56:01,440
how you would move from just the amount

1369
00:56:06,470 --> 00:56:03,760
you need for the analysis to the uh the

1370
00:56:08,309 --> 00:56:06,480
sampling in the field

1371
00:56:11,270 --> 00:56:08,319
you get the gist of my question i get

1372
00:56:13,910 --> 00:56:11,280
the gist of your question david and uh

1373
00:56:17,270 --> 00:56:13,920
you know of course it's a

1374
00:56:18,069 --> 00:56:17,280
tough thing to um sort of fight through

1375
00:56:20,150 --> 00:56:18,079
uh

1376
00:56:22,710 --> 00:56:20,160
when you're not really on you know what

1377
00:56:25,109 --> 00:56:22,720
you'd do if you were there

1378
00:56:26,710 --> 00:56:25,119
and you'd first go out and survey the

1379
00:56:29,589 --> 00:56:26,720
whole area and

1380
00:56:31,430 --> 00:56:29,599
uh frankly the way i would do it would

1381
00:56:33,190 --> 00:56:31,440
be to walk through the area that i was

1382
00:56:35,030 --> 00:56:33,200
going to sample and

1383
00:56:37,349 --> 00:56:35,040
see what was there and get a feel for

1384
00:56:39,750 --> 00:56:37,359
what it was what

1385
00:56:41,910 --> 00:56:39,760
was potentially

1386
00:56:44,950 --> 00:56:41,920
collectible

1387
00:56:48,870 --> 00:56:44,960
then i would come back and

1388
00:56:51,030 --> 00:56:48,880

spend enough time at each of the

1389
00:56:52,630 --> 00:56:51,040
tampa localities that i'd previously

1390
00:56:55,030 --> 00:56:52,640
identified

1391
00:56:57,270 --> 00:56:55,040
in one given area

1392
00:56:59,589 --> 00:56:57,280
and

1393
00:57:01,030 --> 00:56:59,599
for detection of fossils such as i've

1394
00:57:05,190 --> 00:57:01,040
shown here

1395
00:57:07,589 --> 00:57:05,200
um i would concentrate on uh cherts if

1396
00:57:11,349 --> 00:57:07,599
you have to find them

1397
00:57:13,270 --> 00:57:11,359
i would concentrate on fine grain shirts

1398
00:57:14,789 --> 00:57:13,280
because at least

1399
00:57:17,589 --> 00:57:14,799
surficially

1400
00:57:19,910 --> 00:57:17,599
you can get a feel for whether the rock

1401
00:57:21,670 --> 00:57:19,920
has been recrystallized

1402
00:57:23,430 --> 00:57:21,680
and i'm assuming that you have a hand

1403
00:57:25,430 --> 00:57:23,440
lens and you look at it and if it's sort

1404
00:57:27,190 --> 00:57:25,440
of a sugary

1405
00:57:29,190 --> 00:57:27,200
texture you say well it's probably been

1406
00:57:32,309 --> 00:57:29,200
recrystallized if you could find some

1407
00:57:34,150 --> 00:57:32,319
stuff that was really glassy and very

1408
00:57:36,309 --> 00:57:34,160
fine grain

1409
00:57:37,990 --> 00:57:36,319
that's what you'd concentrate on

1410
00:57:39,430 --> 00:57:38,000
because there'd be a higher probability

1411
00:57:42,630 --> 00:57:39,440
of preservation

1412
00:57:43,750 --> 00:57:42,640
uh although i must say that these uh

1413
00:57:46,950 --> 00:57:43,760

rocks from

1414
00:57:48,710 --> 00:57:46,960
uh the lesser himalaya uh were fairly

1415
00:57:50,069 --> 00:57:48,720
sugary and it's a sort of place nobody

1416
00:57:51,750 --> 00:57:50,079
had ever found any fossils there and

1417
00:57:55,109 --> 00:57:51,760
it's not the sort of place that you

1418
00:57:56,390 --> 00:57:55,119
would really necessarily look

1419
00:57:57,670 --> 00:57:56,400
then

1420
00:58:00,630 --> 00:57:57,680
you would

1421
00:58:03,829 --> 00:58:00,640
want to concentrate on

1422
00:58:05,829 --> 00:58:03,839
dark preferably black shirts

1423
00:58:07,990 --> 00:58:05,839
and the reason for that of course is

1424
00:58:09,750 --> 00:58:08,000
that although there are lots of opaque

1425
00:58:12,150 --> 00:58:09,760
minerals

1426
00:58:13,829 --> 00:58:12,160
pyrite for example

1427
00:58:15,910 --> 00:58:13,839
and lots of other opaque minerals that

1428
00:58:17,670 --> 00:58:15,920
will make a church black and the black

1429
00:58:19,109 --> 00:58:17,680
tert doesn't necessarily have organic

1430
00:58:22,549 --> 00:58:19,119
matter in it

1431
00:58:25,349 --> 00:58:22,559
it's going to be

1432
00:58:26,710 --> 00:58:25,359
dark brown to black in color

1433
00:58:29,190 --> 00:58:26,720
and

1434
00:58:31,589 --> 00:58:29,200
another trick that we use in the field

1435
00:58:33,910 --> 00:58:31,599
is to chip off a little piece you can

1436
00:58:36,230 --> 00:58:33,920
chip off a little piece of uh because

1437
00:58:38,309 --> 00:58:36,240
this stuff has a conchoidal fracture to

1438
00:58:40,549 --> 00:58:38,319

it uh you chip off a little piece and

1439
00:58:43,109 --> 00:58:40,559
then hold it hold it up to light and you

1440
00:58:45,109 --> 00:58:43,119
can if you see through it you can get an

1441
00:58:47,670 --> 00:58:45,119
eyeball a color of the organic matter

1442
00:58:50,390 --> 00:58:47,680
and get an idea just very superficially

1443
00:58:54,069 --> 00:58:50,400
of the degree of preservation so it's

1444
00:58:56,789 --> 00:58:54,079
those sorts of of tricks and

1445
00:58:58,549 --> 00:58:56,799
i would think that it would be really

1446
00:59:01,349 --> 00:58:58,559
important

1447
00:59:05,829 --> 00:59:03,109
to really

1448
00:59:07,829 --> 00:59:05,839
high-grade the specimens

1449
00:59:10,470 --> 00:59:07,839
remember that there are other uses as

1450
00:59:12,309 --> 00:59:10,480
well and so you can get chunks of basalt

1451
00:59:14,230 --> 00:59:12,319
and so forth and they'll tell us a good

1452
00:59:15,829 --> 00:59:14,240
deal when they come back as well but

1453
00:59:17,270 --> 00:59:15,839
you'd like sedimentary rocks if you

1454
00:59:18,710 --> 00:59:17,280
could get them

1455
00:59:22,789 --> 00:59:18,720
one other thing

1456
00:59:25,270 --> 00:59:22,799
is that i've always learned that

1457
00:59:27,750 --> 00:59:25,280
for me anyway

1458
00:59:29,829 --> 00:59:27,760
the second and even the third time i go

1459
00:59:32,950 --> 00:59:29,839
back to a given site

1460
00:59:33,750 --> 00:59:32,960
tends to be much more productive

1461
00:59:36,309 --> 00:59:33,760
than

1462
00:59:38,870 --> 00:59:36,319
going just once you go once you bring

1463
00:59:41,270 --> 00:59:38,880

the rocks home you find out what's in it

1464
00:59:42,710 --> 00:59:41,280
and then you get a better idea of what

1465
00:59:45,349 --> 00:59:42,720
to collect and what you should

1466
00:59:47,430 --> 00:59:45,359
concentrate on and the second time you

1467
00:59:49,270 --> 00:59:47,440
asked different questions in the field

1468
00:59:51,349 --> 00:59:49,280
then you asked the first time because

1469
00:59:53,829 --> 00:59:51,359
now you're a little smarter about what's

1470
00:59:55,750 --> 00:59:53,839
going on and the third time you're there

1471
00:59:57,750 --> 00:59:55,760
uh you can do a much better job than

1472
01:00:07,990 --> 00:59:57,760
either the first or second time that's

1473
01:00:11,750 --> 01:00:10,390
dave we have a question here at nai

1474
01:00:16,309 --> 01:00:11,760
central

1475
01:00:19,510 --> 01:00:16,319
hi dave morrison um when we talk about

1476
01:00:21,910 --> 01:00:19,520
worry i should say about possible

1477
01:00:23,990 --> 01:00:21,920
back contamination from mars

1478
01:00:26,470 --> 01:00:24,000
one sometimes talks about doing nasty

1479
01:00:28,789 --> 01:00:26,480
things to the samples like eating them

1480
01:00:31,750 --> 01:00:28,799
so that they would be safe is there any

1481
01:00:33,990 --> 01:00:31,760
process heating radiation or whatever

1482
01:00:36,309 --> 01:00:34,000
that would degrade the evidence you

1483
01:00:38,549 --> 01:00:36,319
talked about

1484
01:00:41,349 --> 01:00:38,559
uh hi david uh

1485
01:00:44,309 --> 01:00:41,359
there certainly is and uh you would

1486
01:00:46,069 --> 01:00:44,319
certainly like to avoid

1487
01:00:48,710 --> 01:00:46,079
heating of the

1488
01:00:51,510 --> 01:00:48,720

specimens i mean the the honest to

1489
01:00:53,910 --> 01:00:51,520
goodness fact is folks that if we wanted

1490
01:00:57,109 --> 01:00:53,920
to really sterilize these things we

1491
01:00:58,789 --> 01:00:57,119
could heat them to incandescents

1492
01:01:01,430 --> 01:00:58,799
but that ain't going to do any good

1493
01:01:02,710 --> 01:01:01,440
because you destroy all the evidence and

1494
01:01:05,190 --> 01:01:02,720
even

1495
01:01:07,990 --> 01:01:05,200
heating them

1496
01:01:09,829 --> 01:01:08,000
gee whiz up to a couple hundred degrees

1497
01:01:12,069 --> 01:01:09,839
is going to alter the organic matter if

1498
01:01:15,190 --> 01:01:12,079
there's organic matter in them so i'd

1499
01:01:18,549 --> 01:01:17,670
the last study group i was on

1500
01:01:20,549 --> 01:01:18,559
uh

1501
01:01:22,829 --> 01:01:20,559
was pretty well convinced that gamma

1502
01:01:26,230 --> 01:01:22,839
irradiation was the way to

1503
01:01:28,870 --> 01:01:26,240
go and uh i don't know whether there

1504
01:01:31,270 --> 01:01:28,880
have been a set of studies since then

1505
01:01:33,750 --> 01:01:31,280
uh that would

1506
01:01:38,870 --> 01:01:33,760
take care of that or not

1507
01:01:42,390 --> 01:01:38,880
but gamma radiation as i recall uh

1508
01:01:43,510 --> 01:01:42,400
works in in on dna uh

1509
01:01:46,470 --> 01:01:43,520
certainly on

1510
01:01:49,190 --> 01:01:46,480
dna of the sort we have on earth and

1511
01:01:52,069 --> 01:01:49,200
decouples these dna and really fouls up

1512
01:01:54,150 --> 01:01:52,079
the nitrogenous bases and is a real good

1513
01:01:55,349 --> 01:01:54,160

sterilizer and it is right it is

1514
01:01:58,710 --> 01:01:55,359
penetrating

1515
01:02:00,789 --> 01:01:58,720
uh so uh that's the way i would prefer

1516
01:02:02,630 --> 01:02:00,799
to go but not heating please don't eat

1517
01:02:08,870 --> 01:02:02,640
them

1518
01:02:12,630 --> 01:02:10,710
are there any other uh questions we

1519
01:02:15,109 --> 01:02:12,640
don't have any hands raised on webex at

1520
01:02:17,750 --> 01:02:15,119
the moment this is a great opportunity

1521
01:02:19,190 --> 01:02:17,760
to quiz bill on this so i see a lot of

1522
01:02:24,950 --> 01:02:19,200
people out there in the audience surely

1523
01:02:30,870 --> 01:02:28,789
carl you're a wonderful cheerleader

1524
01:02:33,349 --> 01:02:30,880
bill you've just you've just wowed them

1525
01:02:35,589 --> 01:02:33,359
i guess that's the only explanation

1526
01:02:37,910 --> 01:02:35,599
if anybody's got a question even without

1527
01:02:40,390 --> 01:02:37,920
raising your hand on webex you can just

1528
01:02:42,390 --> 01:02:40,400
barge in here

1529
01:02:43,910 --> 01:02:42,400
okay bill i'll i'll try another one on

1530
01:02:45,750 --> 01:02:43,920
you um

1531
01:02:47,750 --> 01:02:45,760
mars is different from the earth and i

1532
01:02:50,470 --> 01:02:47,760
think in ways that could be relevant to

1533
01:02:51,990 --> 01:02:50,480
your discussion uh clearly on the earth

1534
01:02:54,390 --> 01:02:52,000
with the older samples thermal

1535
01:02:56,710 --> 01:02:54,400
alteration has you know as you said a

1536
01:02:57,990 --> 01:02:56,720
very important consideration but of

1537
01:02:59,910 --> 01:02:58,000
course one of the reasons we're

1538
01:03:02,230 --> 01:02:59,920

fascinated with mars is that it has a

1539
01:03:04,549 --> 01:03:02,240
really ancient crust as evidenced by the

1540
01:03:06,870 --> 01:03:04,559
allen hills meteorite that really has

1541
01:03:08,549 --> 01:03:06,880
not been altered thermally very much in

1542
01:03:11,030 --> 01:03:08,559
places certainly your comment about

1543
01:03:12,950 --> 01:03:11,040
impacts is well taken but it seems with

1544
01:03:14,630 --> 01:03:12,960
the rovers we have the ability to find

1545
01:03:15,829 --> 01:03:14,640
stuff that has been only marginally

1546
01:03:18,390 --> 01:03:15,839
heated

1547
01:03:20,470 --> 01:03:18,400
the bigger challenge on mars seems to be

1548
01:03:21,349 --> 01:03:20,480
that unlike on the earth the the water

1549
01:03:24,950 --> 01:03:21,359
and the

1550
01:03:27,109 --> 01:03:24,960
rocks has not been as thorough in many

1551
01:03:28,309 --> 01:03:27,119
cases in which case this ripening effect

1552
01:03:29,829 --> 01:03:28,319
that you talked about like with the

1553
01:03:31,990 --> 01:03:29,839
carbonate grains

1554
01:03:34,069 --> 01:03:32,000
maybe is not as pervasive in sedimentary

1555
01:03:35,750 --> 01:03:34,079
rocks on mars as has been the case on

1556
01:03:38,230 --> 01:03:35,760
the earth we're we're sort of used to

1557
01:03:40,309 --> 01:03:38,240
these old rocks being well lithified and

1558
01:03:42,630 --> 01:03:40,319
that's probably largely due to this die

1559
01:03:44,390 --> 01:03:42,640
genetic processing and tightening up of

1560
01:03:46,230 --> 01:03:44,400
the rock fabric so

1561
01:03:48,069 --> 01:03:46,240
in the case of mars

1562
01:03:50,230 --> 01:03:48,079
we might have rocks that are relatively

1563
01:03:51,829 --> 01:03:50,240

poorly lithified so the good news is

1564
01:03:53,750 --> 01:03:51,839
that they haven't maybe been heated as

1565
01:03:55,349 --> 01:03:53,760
much or there's at least ones around

1566
01:03:57,270 --> 01:03:55,359
that haven't been heated as much but the

1567
01:03:59,990 --> 01:03:57,280
lithification process may not be as

1568
01:04:03,029 --> 01:04:00,000
efficient as as on the earth so

1569
01:04:04,870 --> 01:04:03,039
potentially oxidation and pervasion you

1570
01:04:06,710 --> 01:04:04,880
know these things being pervaded by

1571
01:04:08,630 --> 01:04:06,720
fluids that would alter them is a is a

1572
01:04:10,390 --> 01:04:08,640
bigger problem so

1573
01:04:13,270 --> 01:04:10,400
the good news is that low thermal

1574
01:04:15,270 --> 01:04:13,280
processing perhaps low recrystallization

1575
01:04:17,270 --> 01:04:15,280
or loss of textures but the bad news

1576
01:04:18,630 --> 01:04:17,280
might be permeability

1577
01:04:20,390 --> 01:04:18,640
the good news also is that we've just

1578
01:04:22,630 --> 01:04:20,400
discovered silica as you know both

1579
01:04:25,109 --> 01:04:22,640
spirit as well as remote sensing

1580
01:04:27,349 --> 01:04:25,119
observations now find silica deposits

1581
01:04:29,270 --> 01:04:27,359
may be pervasive around the cosmoda and

1582
01:04:30,870 --> 01:04:29,280
the valles marinara so

1583
01:04:32,150 --> 01:04:30,880
mars is sort of different from the earth

1584
01:04:34,390 --> 01:04:32,160
and i just wondered what your thoughts

1585
01:04:35,990 --> 01:04:34,400
might be as to how we would adapt our

1586
01:04:37,510 --> 01:04:36,000
our strategy in the face of some of

1587
01:04:39,109 --> 01:04:37,520
these factors

1588
01:04:40,710 --> 01:04:39,119

it's sort of an open-ended question but

1589
01:04:43,589 --> 01:04:40,720
it'd be interesting to hear your views

1590
01:04:48,150 --> 01:04:43,599
about it yeah and it's and uh of course

1591
01:04:50,390 --> 01:04:48,160
david you have had uh real in-depth uh

1592
01:04:53,510 --> 01:04:50,400
you've been immersed in these studies

1593
01:04:56,390 --> 01:04:53,520
and i've not uh with regard to mars so

1594
01:04:57,589 --> 01:04:56,400
uh your knowledge of it is far surpasses

1595
01:04:59,990 --> 01:04:57,599
my own

1596
01:05:06,789 --> 01:05:04,309
i i think it's a it's well taken and uh

1597
01:05:09,349 --> 01:05:06,799
i personally would imagine that when we

1598
01:05:11,190 --> 01:05:09,359
start bringing stuff back from mars

1599
01:05:13,430 --> 01:05:11,200
uh i think we'd be

1600
01:05:16,630 --> 01:05:13,440
wise to have

1601
01:05:18,150 --> 01:05:16,640
uh maybe a an initial three mission

1602
01:05:22,069 --> 01:05:18,160
strategy

1603
01:05:24,230 --> 01:05:22,079
um and on the second see the first time

1604
01:05:26,870 --> 01:05:24,240
we go out do a survey

1605
01:05:28,710 --> 01:05:26,880
bring certainly bring back carbonates uh

1606
01:05:30,069 --> 01:05:28,720
certainly bring back whatever you can

1607
01:05:33,270 --> 01:05:30,079
bring back in

1608
01:05:36,870 --> 01:05:33,280
as much of a variety as you can

1609
01:05:39,430 --> 01:05:36,880
and then use the the results from that

1610
01:05:41,349 --> 01:05:39,440
study to point you in a more profitable

1611
01:05:43,589 --> 01:05:41,359
direction with regard to certain

1612
01:05:44,710 --> 01:05:43,599
questions like life and the second time

1613
01:05:47,270 --> 01:05:44,720

through

1614
01:05:50,230 --> 01:05:47,280
because we'll know so much more when we

1615
01:05:53,349 --> 01:05:50,240
actually have the rocks in hand to be

1616
01:05:54,309 --> 01:05:53,359
looked at uh it at the moment it's a

1617
01:05:57,829 --> 01:05:54,319
guess

1618
01:05:59,270 --> 01:05:57,839
um and i but i can tell you that uh on

1619
01:06:03,670 --> 01:05:59,280
earth anyway

1620
01:06:06,390 --> 01:06:03,680
uh the obliteration of uh microbes in

1621
01:06:09,349 --> 01:06:06,400
stromatolytic deposits

1622
01:06:12,069 --> 01:06:09,359
as far as i can tell takes place within

1623
01:06:13,990 --> 01:06:12,079
like 12 000 years

1624
01:06:15,510 --> 01:06:14,000
and that's based on a little study that

1625
01:06:16,789 --> 01:06:15,520
i did

1626
01:06:18,549 --> 01:06:16,799
with

1627
01:06:21,750 --> 01:06:18,559
stromatolite

1628
01:06:23,349 --> 01:06:21,760
from pleistocene pluvial lakes

1629
01:06:25,349 --> 01:06:23,359
in ethiopia

1630
01:06:27,270 --> 01:06:25,359
and turns out there were a set there was

1631
01:06:29,349 --> 01:06:27,280
a particular lake that had a set of

1632
01:06:31,190 --> 01:06:29,359
stands of where the water had stood and

1633
01:06:34,150 --> 01:06:31,200
the stromatolites had grown and then it

1634
01:06:37,349 --> 01:06:34,160
it decreased and it decreased uh and we

1635
01:06:39,349 --> 01:06:37,359
had c14 dates on those

1636
01:06:40,230 --> 01:06:39,359
and uh the

1637
01:06:43,910 --> 01:06:40,240
uh

1638
01:06:45,270 --> 01:06:43,920

more most recent we had the samples at 2

1639
01:06:47,990 --> 01:06:45,280
000

1640
01:06:51,029 --> 01:06:48,000
about four thousand and ten thousand and

1641
01:06:52,390 --> 01:06:51,039
uh it was a a sequential degradation and

1642
01:06:55,829 --> 01:06:52,400
by ten thousand

1643
01:06:56,549 --> 01:06:55,839
uh years here under those conditions the

1644
01:06:59,430 --> 01:06:56,559
uh

1645
01:07:01,349 --> 01:06:59,440
the carbonate grains had sealed

1646
01:07:03,910 --> 01:07:01,359
and there was nothing left that you

1647
01:07:06,549 --> 01:07:03,920
could detect at all and maybe at four

1648
01:07:08,630 --> 01:07:06,559
thousand as i require we recall

1649
01:07:11,910 --> 01:07:08,640
you could see bits and pieces of

1650
01:07:14,870 --> 01:07:11,920
microbes but not whole specimens and at

1651
01:07:17,990 --> 01:07:14,880
2000 you could still make out some

1652
01:07:20,069 --> 01:07:18,000
some decent specimens

1653
01:07:21,910 --> 01:07:20,079
but i think your point of course is well

1654
01:07:23,510 --> 01:07:21,920
taken and i think we're going to learn a

1655
01:07:24,710 --> 01:07:23,520
lot more

1656
01:07:26,549 --> 01:07:24,720
uh

1657
01:07:30,230 --> 01:07:26,559
hopefully not trying to i think if we're

1658
01:07:33,510 --> 01:07:30,240
smart the strategy ought to be to

1659
01:07:37,670 --> 01:07:33,520
not look at this as a one-shot deal

1660
01:07:40,230 --> 01:07:37,680
don't try to do everything all at once

1661
01:07:43,910 --> 01:07:40,240
say we have a strategy let's go out and

1662
01:07:46,950 --> 01:07:43,920
do a survey of this particular area and

1663
01:07:49,190 --> 01:07:46,960

rock types and the next time out we'll

1664
01:07:51,990 --> 01:07:49,200
we can count on maybe getting back to a

1665
01:07:54,710 --> 01:07:52,000
couple of those that we want to resample

1666
01:07:57,510 --> 01:07:54,720
and move into some other area some some

1667
01:07:59,750 --> 01:07:57,520
deal like that so that you learn

1668
01:08:02,789 --> 01:07:59,760
each time how to do a better job the

1669
01:08:08,630 --> 01:08:02,799
next time and a better job the next time

1670
01:08:13,270 --> 01:08:10,230
bill i'd like to follow up dave's

1671
01:08:15,910 --> 01:08:13,280
question uh one of the rocks that we

1672
01:08:18,229 --> 01:08:15,920
know is available on mars that's well

1673
01:08:20,070 --> 01:08:18,239
consolidated and sedimentary are the

1674
01:08:22,550 --> 01:08:20,080
blueberries which were of course largely

1675
01:08:25,430 --> 01:08:22,560
hematite how would your

1676
01:08:27,269 --> 01:08:25,440
techniques work applied to let's say a

1677
01:08:29,829 --> 01:08:27,279
thin section of a blueberry if we could

1678
01:08:30,789 --> 01:08:29,839
bring it back from mars

1679
01:08:34,789 --> 01:08:30,799
uh

1680
01:08:39,430 --> 01:08:34,799
the

1681
01:08:40,789 --> 01:08:39,440
without any problem

1682
01:08:44,149 --> 01:08:40,799
um

1683
01:08:45,189 --> 01:08:44,159
if it is optically opaque

1684
01:08:48,630 --> 01:08:45,199
uh

1685
01:08:49,669 --> 01:08:48,640
then i don't i and oh i have no idea

1686
01:08:51,189 --> 01:08:49,679
what the

1687
01:08:53,269 --> 01:08:51,199
the uh

1688
01:08:54,390 --> 01:08:53,279

fluorescence characteristics of hematite

1689
01:08:57,030 --> 01:08:54,400
are although i don't think it's

1690
01:08:59,430 --> 01:08:57,040
fluorescent okay so i don't know that

1691
01:09:00,950 --> 01:08:59,440
clsm uh would be a much help now it

1692
01:09:03,590 --> 01:09:00,960
depends on

1693
01:09:06,630 --> 01:09:03,600
what matrix it's in if it's a solid

1694
01:09:09,110 --> 01:09:06,640
hematite ball that's one thing if it is

1695
01:09:11,030 --> 01:09:09,120
a particulate hematite

1696
01:09:13,349 --> 01:09:11,040
like you find in iron formations which

1697
01:09:15,349 --> 01:09:13,359
is then solicified that's something

1698
01:09:19,269 --> 01:09:15,359
altogether different and that would be

1699
01:09:22,950 --> 01:09:21,030
carl this is dave i could add to that in

1700
01:09:25,349 --> 01:09:22,960
the sense that hematite becomes

1701
01:09:27,030 --> 01:09:25,359
transparent in the infrared so the trick

1702
01:09:28,550 --> 01:09:27,040
with uh some kind of a fluorescence

1703
01:09:29,990 --> 01:09:28,560
technique would be i don't know i mean

1704
01:09:32,229 --> 01:09:30,000
if you could excite something at the in

1705
01:09:33,189 --> 01:09:32,239
the infrared range that might be fun to

1706
01:09:44,470 --> 01:09:33,199
explore

1707
01:09:51,669 --> 01:09:47,269
okay one last opportunity to

1708
01:09:54,630 --> 01:09:53,990
going once going twice well bill thank

1709
01:09:57,910 --> 01:09:54,640
you

1710
01:10:00,790 --> 01:09:57,920
in closing in closing

1711
01:10:03,350 --> 01:10:00,800
uh just let me say it's awfully nice of

1712
01:10:06,229 --> 01:10:03,360
all you guys to take uh time from your

1713
01:10:08,310 --> 01:10:06,239

busy schedules to listen to me you know

1714
01:10:09,910 --> 01:10:08,320
i know you've got things that

1715
01:10:11,669 --> 01:10:09,920
are more pressing

1716
01:10:13,990 --> 01:10:11,679
things that are

1717
01:10:15,750 --> 01:10:14,000
like your science and your teaching and

1718
01:10:18,630 --> 01:10:15,760
all that and i think it's very kind of

1719
01:10:20,870 --> 01:10:18,640
you to uh has spent this hour and a half

1720
01:10:23,430 --> 01:10:20,880
and i think we ought to thank uh carl

1721
01:10:24,310 --> 01:10:23,440
pilcher myself because uh

1722
01:10:25,430 --> 01:10:24,320
uh

1723
01:10:27,590 --> 01:10:25,440
he's

1724
01:10:29,669 --> 01:10:27,600
listened to these next two talks i'll

1725
01:10:31,350 --> 01:10:29,679
tell you they're going to be exciting

1726
01:10:33,669 --> 01:10:31,360
and it's awful good that we've got a

1727
01:10:35,830 --> 01:10:33,679
director of this outfit that

1728
01:10:38,950 --> 01:10:35,840
is bringing together all these things i

1729
01:10:40,790 --> 01:10:38,960
appreciate it a lot so thanks for me