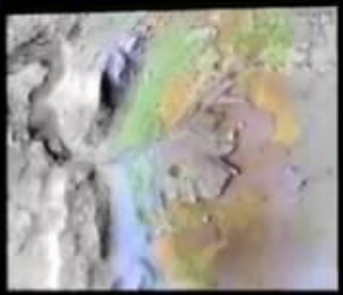
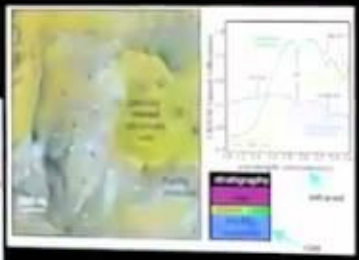
Evidence for past water

Both shape and minerology show that water once flowed.

Phyllosilicate clays require water to form. Evidence of an aqueous formation enviroment?





1
00:00:11,610 --> 00:00:08,910
we have the first part of our session

2
00:00:13,920 --> 00:00:11,620
today talks about exoplanets I'm so

3
00:00:15,990 --> 00:00:13,930
planets around other stars and how we're

4
00:00:18,359 --> 00:00:16,000
beginning to characterize them the

5
00:00:20,460 --> 00:00:18,369
second half of the sessions that we have

6
00:00:22,260 --> 00:00:20,470
today talks a little bit about earth

7
00:00:24,750 --> 00:00:22,270
analog environments for the planets in

8
00:00:27,210 --> 00:00:24,760
our own system so I wanted to go through

9
00:00:29,700 --> 00:00:27,220
a little bit of an introduction on what

10
00:00:32,009 --> 00:00:29,710
we have on the earth that allows us to

11
00:00:35,610 --> 00:00:32,019
learn about other planets and other

12
00:00:39,030 --> 00:00:35,620
objects in our solar system so the first

13
00:00:45,000 --> 00:00:39,040

question this might not work all right

14
00:00:47,969 --> 00:00:45,010
that's fine I'll stand over here great

15
00:00:49,680 --> 00:00:47,979
okay all right so we'll always will

16
00:00:51,469 --> 00:00:49,690
probably always have more data on the

17
00:00:54,450 --> 00:00:51,479
earth that we have one of anything else

18
00:00:56,130 --> 00:00:54,460
we're all here on the planet Earth it's

19
00:00:57,810 --> 00:00:56,140
much easier to get to places on the

20
00:00:59,490 --> 00:00:57,820
planet Earth than it is to go anywhere

21
00:01:00,869 --> 00:00:59,500
else so as much as we're all super

22
00:01:02,700 --> 00:01:00,879
interested in stuff which is not on

23
00:01:05,219 --> 00:01:02,710
earth if we can find a place on earth

24
00:01:08,090 --> 00:01:05,229
which looks very like the place that we

25
00:01:10,200 --> 00:01:08,100
would prefer to be then that's great

26
00:01:12,420 --> 00:01:10,210
also earth is the only planet with

27
00:01:15,539 --> 00:01:12,430
ubiquitous life right so we have an

28
00:01:17,880 --> 00:01:15,549
example here of an inhabited world and

29
00:01:19,230 --> 00:01:17,890
if we go anywhere on the earth right so

30
00:01:20,910 --> 00:01:19,240
far everywhere we've gone we've been

31
00:01:24,029 --> 00:01:20,920
able to find some organism which is

32
00:01:26,249 --> 00:01:24,039
living there thriving there so if you

33
00:01:28,349 --> 00:01:26,259
can go to an environment which is very

34
00:01:31,139 --> 00:01:28,359
like the surface of Mars say or very

35
00:01:33,419 --> 00:01:31,149
like the subsurface ocean on Europa and

36
00:01:35,730 --> 00:01:33,429
find life there well maybe you found

37
00:01:38,849 --> 00:01:35,740
candidate organisms that we might

38
00:01:40,889 --> 00:01:38,859

someday find on those other planets and

39
00:01:42,690 --> 00:01:40,899
then the other great thing about Earth

40
00:01:44,370 --> 00:01:42,700
is that we've been sort of in this

41
00:01:46,709 --> 00:01:44,380
cosmic minefield for four and a half

42
00:01:48,270 --> 00:01:46,719
billion years scooping up little bits of

43
00:01:50,370 --> 00:01:48,280
other planets that happen to be

44
00:01:53,039 --> 00:01:50,380
wandering around the solar system so

45
00:01:55,889 --> 00:01:53,049
we've got two talks this afternoon about

46
00:01:57,029 --> 00:01:55,899
Martian meteorites and then additional

47
00:01:59,399 --> 00:01:57,039
talks which are about meteorites which

48
00:02:01,200 --> 00:01:59,409
aren't from Mars these are samples of

49
00:02:03,149 --> 00:02:01,210
the rest of the universe which have

50
00:02:05,389 --> 00:02:03,159
landed on the earth and then been found

51
00:02:08,760 --> 00:02:05,399
by scientists and these are great

52
00:02:10,490 --> 00:02:08,770
laboratories for studying these objects

53
00:02:13,740 --> 00:02:10,500
because so far the only thing we've done

54
00:02:15,839 --> 00:02:13,750
to bring back parts of other objects in

55
00:02:18,970 --> 00:02:15,849
the solar system is bring back tiny I

56
00:02:23,360 --> 00:02:18,980
screens from a comment

57
00:02:24,620 --> 00:02:23,370
okay so a little bit about meteorites so

58
00:02:27,980 --> 00:02:24,630
there's a bunch of different classes of

59
00:02:30,050 --> 00:02:27,990
meteorite maybe the most important when

60
00:02:32,360 --> 00:02:30,060
you talk about the chemicals of life or

61
00:02:34,370 --> 00:02:32,370
finding chemicals of life in the

62
00:02:37,160 --> 00:02:34,380
universe are these carbonaceous

63
00:02:40,610 --> 00:02:37,170

chondrites so they're called chondrites

64
00:02:43,940 --> 00:02:40,620
because they have con jewels here's a

65
00:02:45,050 --> 00:02:43,950
con drool right this little speck here

66
00:02:47,540 --> 00:02:45,060
and there's lots of these other little

67
00:02:50,500 --> 00:02:47,550
circular spherical inclusions in

68
00:02:52,580 --> 00:02:50,510
meteorites which are called chondrules I

69
00:02:54,920 --> 00:02:52,590
don't know why they're called chondrules

70
00:02:57,890 --> 00:02:54,930
it comes from like some greek root

71
00:02:59,300 --> 00:02:57,900
probably that means spherical so the

72
00:03:02,240 --> 00:02:59,310
chondrules are surrounded by this dark

73
00:03:03,560 --> 00:03:02,250
matrix so if people talk about the

74
00:03:06,200 --> 00:03:03,570
matrix they're not talking about that

75
00:03:08,450 --> 00:03:06,210
movie they're talking about this dark

76
00:03:09,710 --> 00:03:08,460
organic rich material which cements

77
00:03:12,890 --> 00:03:09,720
together everything else in the

78
00:03:14,870 --> 00:03:12,900
meteorite so organics are most abundant

79
00:03:17,360 --> 00:03:14,880
in the matrix of chondritic meteorites

80
00:03:18,920 --> 00:03:17,370
or carbonaceous chondrites i'm so called

81
00:03:22,610 --> 00:03:18,930
because they have a lot of carbon that's

82
00:03:24,680 --> 00:03:22,620
what makes them black so if you actually

83
00:03:27,229 --> 00:03:24,690
go and scoop out a little bit of this

84
00:03:29,150 --> 00:03:27,239
matrix and look for organic molecules

85
00:03:32,360 --> 00:03:29,160
amino acids what have you you'll find

86
00:03:34,070 --> 00:03:32,370
them there so here's just a list of a

87
00:03:36,380 --> 00:03:34,080
whole bunch of different compounds which

88
00:03:37,760 --> 00:03:36,390

have been found in i believe the

89
00:03:40,310 --> 00:03:37,770
merchants and meteorite and this is a

90
00:03:42,770 --> 00:03:40,320
picture of the Murchison meteorite here

91
00:03:45,920 --> 00:03:42,780
I'm zsuzsa meteorite which fell in

92
00:03:48,350 --> 00:03:45,930
Australia people saw this streak of a

93
00:03:51,410 --> 00:03:48,360
meteorite meteor streaking across the

94
00:03:53,930 --> 00:03:51,420
sky landed just outside of town and like

95
00:03:55,970 --> 00:03:53,940
the whole town drove out there and their

96
00:03:57,560 --> 00:03:55,980
pickup trucks and found the meteorite

97
00:04:01,130 --> 00:03:57,570
some people reported that it had a very

98
00:04:02,540 --> 00:04:01,140
strong smell like ammonia and then they

99
00:04:04,699 --> 00:04:02,550
loaded it in the back of a pickup truck

100
00:04:06,410 --> 00:04:04,709
brought it into town put it in a bank

101
00:04:09,110 --> 00:04:06,420
vault and immediately called the

102
00:04:13,040 --> 00:04:09,120
scientists like a hundred percent

103
00:04:15,920 --> 00:04:13,050
correct great job because these people

104
00:04:17,690 --> 00:04:15,930
preserve the meteorite from alteration

105
00:04:19,120 --> 00:04:17,700
most meteorites that we find have been

106
00:04:21,530 --> 00:04:19,130
sitting there for god knows how long

107
00:04:24,320 --> 00:04:21,540
they've been subject to weathering on

108
00:04:26,480 --> 00:04:24,330
the Earth's surface but these people got

109
00:04:28,730 --> 00:04:26,490
there in time to smell the organics

110
00:04:30,230 --> 00:04:28,740
coming off of the meteorite and then

111
00:04:31,140 --> 00:04:30,240
they immediately put it in a sterile

112
00:04:35,760 --> 00:04:31,150
environment and call

113
00:04:37,560 --> 00:04:35,770

the experts so here's an example of

114
00:04:38,790 --> 00:04:37,570
stuff that's been found in these

115
00:04:40,440 --> 00:04:38,800
meteorites if you're sufficiently

116
00:04:42,420 --> 00:04:40,450
impressive you can like right away to

117
00:04:44,910 --> 00:04:42,430
NASA and say please send me part of a

118
00:04:46,860 --> 00:04:44,920
meteorite and they will send you part of

119
00:04:49,500 --> 00:04:46,870
a meteorite um you can also go and buy

120
00:04:51,840 --> 00:04:49,510
slightly less rare meteorites at your

121
00:04:53,670 --> 00:04:51,850
local gem and mineral show so if you

122
00:04:55,500 --> 00:04:53,680
haven't like an extra 50 bucks and you

123
00:04:59,670 --> 00:04:55,510
want a piece of space you can go there

124
00:05:02,610 --> 00:04:59,680
and purchase one yeah so in addition to

125
00:05:04,890 --> 00:05:02,620
just finding this stuff in these in the

126
00:05:08,870 --> 00:05:04,900
matrix of these meteorites you can also

127
00:05:11,430 --> 00:05:08,880
do a lot of detailed analysis of the

128
00:05:13,620 --> 00:05:11,440
particular kinds of amino acids that

129
00:05:15,330 --> 00:05:13,630
you're finding the particular abundances

130
00:05:17,790 --> 00:05:15,340
of the organic molecules that you find

131
00:05:19,350 --> 00:05:17,800
and the abundances that you see might

132
00:05:21,510 --> 00:05:19,360
give clues to the formation conditions

133
00:05:23,520 --> 00:05:21,520
so basically you build a laboratory

134
00:05:25,530 --> 00:05:23,530
meteorite under a bunch of different

135
00:05:27,360 --> 00:05:25,540
temperature pressure conditions you run

136
00:05:29,220 --> 00:05:27,370
a bunch of syntheses and you see what

137
00:05:30,750 --> 00:05:29,230
you get out in terms of the abundance of

138
00:05:33,240 --> 00:05:30,760

the amino acids that you produce and

139
00:05:34,260 --> 00:05:33,250
this might tell you something about what

140
00:05:35,730 --> 00:05:34,270
the conditions were like in the

141
00:05:39,420 --> 00:05:35,740
meteorite when those amino acids were

142
00:05:42,450 --> 00:05:39,430
forming and in addition some people

143
00:05:45,960 --> 00:05:42,460
think that these organic molecules were

144
00:05:47,940 --> 00:05:45,970
the seeds of life so life and organic

145
00:05:49,860 --> 00:05:47,950
molecules didn't begin on the earth it

146
00:05:51,750 --> 00:05:49,870
began in meteorites and then was brought

147
00:05:56,010 --> 00:05:51,760
to the earth and then the organic

148
00:05:57,300 --> 00:05:56,020
molecules provided the start of life I

149
00:05:58,890 --> 00:05:57,310
mean I don't know if you've seen

150
00:06:01,590 --> 00:05:58,900
recently it's been going around on

151
00:06:04,020 --> 00:06:01,600
facebook and all over the place like

152
00:06:06,510 --> 00:06:04,030
scientists old 3.5 billion year old

153
00:06:09,330 --> 00:06:06,520
mystery of life and it's basically one

154
00:06:11,340 --> 00:06:09,340
particular group has this idea that if

155
00:06:14,220 --> 00:06:11,350
only they could get a fancy kind of

156
00:06:15,690 --> 00:06:14,230
phosphate they could make life and then

157
00:06:18,330 --> 00:06:15,700
they said let's just get it from

158
00:06:20,580 --> 00:06:18,340
meteorites we'll bring it all in from

159
00:06:22,050 --> 00:06:20,590
outer space all these meteorites will in

160
00:06:24,420 --> 00:06:22,060
on the earth and give us the phosphates

161
00:06:28,020 --> 00:06:24,430
that we need in order to start life out

162
00:06:30,810 --> 00:06:28,030
so not so much solving a 3.5 billion

163
00:06:34,080 --> 00:06:30,820

year old mystery as pushing it back a

164
00:06:41,210 --> 00:06:34,090
step to actually being in the meteorites

165
00:06:44,100 --> 00:06:41,220
and now I need to log in again all right

166
00:06:45,740 --> 00:06:44,110
okay so questions worth asking when we

167
00:06:47,820 --> 00:06:45,750
talk about amino acids and meteorites

168
00:06:49,350 --> 00:06:47,830
how well-known are the formation

169
00:06:52,350 --> 00:06:49,360
mechanisms right so we talked about

170
00:06:54,720 --> 00:06:52,360
maybe characterizing a meteorite on the

171
00:06:56,280 --> 00:06:54,730
basis of running a bunch of reactions in

172
00:06:58,530 --> 00:06:56,290
the lab right you can only run certain

173
00:07:00,090 --> 00:06:58,540
reactions so how well do we know what

174
00:07:01,830 --> 00:07:00,100
mechanisms might have been operating in

175
00:07:03,960 --> 00:07:01,840
the meteorites when the amino acids

176
00:07:07,320 --> 00:07:03,970
actually formed and if we're looking at

177
00:07:10,080 --> 00:07:07,330
meteorites is a source for for what

178
00:07:11,790 --> 00:07:10,090
happened early on in Earth history maybe

179
00:07:13,200 --> 00:07:11,800
a source for the phosphates are the

180
00:07:15,180 --> 00:07:13,210
organic molecules that you need to get

181
00:07:16,740 --> 00:07:15,190
life going it's worthwhile to ask

182
00:07:18,390 --> 00:07:16,750
whether the meteorites that fell on

183
00:07:20,160 --> 00:07:18,400
earth when life was beginning even or

184
00:07:21,570 --> 00:07:20,170
even still around right the Earth's

185
00:07:23,060 --> 00:07:21,580
surface has been highly processed over

186
00:07:25,890 --> 00:07:23,070
the last four and a half billion years

187
00:07:27,630 --> 00:07:25,900
maybe we don't even have samples of the

188
00:07:29,690 --> 00:07:27,640

stuff that fell on the earth and might

189
00:07:31,740 --> 00:07:29,700
have gotten life started um and

190
00:07:34,070 --> 00:07:31,750
questions always worth asking whenever

191
00:07:36,510 --> 00:07:34,080
people say oh life came from space is

192
00:07:40,530 --> 00:07:36,520
what would there have even been a high

193
00:07:43,140 --> 00:07:40,540
enough impact flux right to matter could

194
00:07:45,240 --> 00:07:43,150
you ever have put enough stuff on the

195
00:07:47,280 --> 00:07:45,250
surface of the earth that you could get

196
00:07:50,310 --> 00:07:47,290
these things started so even if you have

197
00:07:53,130 --> 00:07:50,320
no idea what people to say in the talk

198
00:07:55,200 --> 00:07:53,140
on meteorites or origin of life beyond

199
00:07:57,120 --> 00:07:55,210
Earth you can ask any of these questions

200
00:08:00,870 --> 00:07:57,130
and they better have a good answer at

201
00:08:03,600 --> 00:08:00,880
least a scientific sounding answer okay

202
00:08:05,370 --> 00:08:03,610
so another analog environment that

203
00:08:08,220 --> 00:08:05,380
people look at Britney this afternoon is

204
00:08:11,790 --> 00:08:08,230
going to be talking about ice and in

205
00:08:13,650 --> 00:08:11,800
particular life under ice um so some

206
00:08:16,050 --> 00:08:13,660
people think that if you want to get

207
00:08:19,310 --> 00:08:16,060
life started you need oh Sh ins worth of

208
00:08:22,200 --> 00:08:19,320
water in contact with a silicate

209
00:08:24,150 --> 00:08:22,210
exterior of a planet right so it's not

210
00:08:27,440 --> 00:08:24,160
enough to just have like one pond on the

211
00:08:29,760 --> 00:08:27,450
surface of Mars you need a whole ocean

212
00:08:31,800 --> 00:08:29,770
not everybody is on board with that but

213
00:08:34,770 --> 00:08:31,810

some people really believe that you need

214
00:08:36,990 --> 00:08:34,780
a whole ocean and in contact with a

215
00:08:38,640 --> 00:08:37,000
silicate crust and if you believe that

216
00:08:41,160 --> 00:08:38,650
then one of the best places to look for

217
00:08:44,760 --> 00:08:41,170
life in the solar system may be in the

218
00:08:47,250 --> 00:08:44,770
universe are the Jovian moons because

219
00:08:49,230 --> 00:08:47,260
they actually have more water in contact

220
00:08:51,810 --> 00:08:49,240
with more silicate mantle than the earth

221
00:08:53,460 --> 00:08:51,820
does so

222
00:08:55,680 --> 00:08:53,470
if you believe that life can only begin

223
00:08:58,260 --> 00:08:55,690
when you have an ocean in contact with a

224
00:09:00,300 --> 00:08:58,270
silicate crust then you want to go

225
00:09:01,650 --> 00:09:00,310
Europa and look for stuff there and

226
00:09:06,450 --> 00:09:01,660
there's a couple places so let's go

227
00:09:08,010 --> 00:09:06,460
let's go to Europa so if you're on the

228
00:09:09,420 --> 00:09:08,020
surface of Europa right there are a

229
00:09:12,000 --> 00:09:09,430
couple ideas for where you might have

230
00:09:15,240 --> 00:09:12,010
your like cactus right living here

231
00:09:17,520 --> 00:09:15,250
getting some sunlight but you need to

232
00:09:19,620 --> 00:09:17,530
always be asking where the nutrients

233
00:09:21,270 --> 00:09:19,630
coming from where are the oxidants

234
00:09:23,940 --> 00:09:21,280
coming from where the reductants coming

235
00:09:27,060 --> 00:09:23,950
from complex life on earth requires

236
00:09:31,650 --> 00:09:27,070
oxygen we get that oxygen from oxygenic

237
00:09:35,970 --> 00:09:31,660
photosynthesis and if you think about

238
00:09:40,770 --> 00:09:35,980

these systems where deep under the

239
00:09:45,510 --> 00:09:40,780
Earth's oceans we have superheated water

240
00:09:48,480 --> 00:09:45,520
but then also oxygen in the oceans which

241
00:09:50,460 --> 00:09:48,490
is acting as a battery that life is

242
00:09:52,260 --> 00:09:50,470
exploiting right so you've got oxidants

243
00:09:54,150 --> 00:09:52,270
coming in from outside you've got

244
00:09:56,850 --> 00:09:54,160
reductants coming out from the inside of

245
00:09:59,550 --> 00:09:56,860
the earth and life can exploit the fact

246
00:10:02,280 --> 00:09:59,560
that oxidation wants to happen in order

247
00:10:05,340 --> 00:10:02,290
to exist but you need an oxidant and you

248
00:10:07,170 --> 00:10:05,350
need a reductant on Europa the idea is

249
00:10:09,630 --> 00:10:07,180
that you can take a whole bunch of stuff

250
00:10:13,080 --> 00:10:09,640
from the ambient environment around

251
00:10:16,650 --> 00:10:13,090
Jupiter smash it into the surface and

252
00:10:19,710 --> 00:10:16,660
then take that stuff under the shell so

253
00:10:21,660 --> 00:10:19,720
that you introduce a lot of oxidants

254
00:10:23,550 --> 00:10:21,670
into the Europa environment and that's

255
00:10:26,940 --> 00:10:23,560
the only way that you could get a source

256
00:10:28,890 --> 00:10:26,950
of oxidation for the life that may or

257
00:10:30,530 --> 00:10:28,900
may not exist inside like your little

258
00:10:34,650 --> 00:10:30,540
cockroaches that may or may not exist

259
00:10:35,760 --> 00:10:34,660
near in the near surface of Europa so I

260
00:10:39,210 --> 00:10:35,770
think Brittany's going to talk about

261
00:10:42,300 --> 00:10:39,220
finding stuff underneath the ice that

262
00:10:44,250 --> 00:10:42,310
has been found in Antarctica so this is

263
00:10:46,020 --> 00:10:44,260

maybe a new environment most people when

264
00:10:47,730 --> 00:10:46,030
they think of Europa they think of this

265
00:10:49,740 --> 00:10:47,740
kind of environment black smoke or deep

266
00:10:51,570 --> 00:10:49,750
underneath the ocean we'd have to send

267
00:10:53,580 --> 00:10:51,580
like a submarine all the way down to the

268
00:10:55,560 --> 00:10:53,590
bottom of the ocean on Europa but maybe

269
00:10:58,470 --> 00:10:55,570
we could find life really close

270
00:10:59,640 --> 00:10:58,480
underneath the ice I'm so questions

271
00:11:01,110 --> 00:10:59,650
worth asking you know where is

272
00:11:03,660 --> 00:11:01,120
everything coming from what's the source

273
00:11:05,190 --> 00:11:03,670
of nutrients oxidants reductants and

274
00:11:07,200 --> 00:11:05,200
energy and

275
00:11:10,350 --> 00:11:07,210
how quickly could any of those be de

276
00:11:14,280 --> 00:11:10,360
plena SH by life we've depleted by life

277
00:11:16,080 --> 00:11:14,290
or replenished by life so you can't just

278
00:11:18,090 --> 00:11:16,090
have all four of these things in one

279
00:11:21,060 --> 00:11:18,100
place for 30 minutes and then you have

280
00:11:22,800 --> 00:11:21,070
life right it may have taken a great

281
00:11:25,260 --> 00:11:22,810
deal of time for life to get started on

282
00:11:26,400 --> 00:11:25,270
the earth so even if you have all four

283
00:11:27,690 --> 00:11:26,410
of these things you need to make sure

284
00:11:29,910 --> 00:11:27,700
that they're there for long enough and

285
00:11:36,000 --> 00:11:29,920
that any life doesn't just get rid of

286
00:11:39,300 --> 00:11:36,010
them right away let's go to Mars so Mars

287
00:11:41,250 --> 00:11:39,310
today is very dry there's lots of

288
00:11:43,350 --> 00:11:41,260

evidence for water in the past but if

289
00:11:45,150 --> 00:11:43,360
you put a cup of liquid water out on the

290
00:11:49,170 --> 00:11:45,160
surface of Mars today it would either

291
00:11:51,000 --> 00:11:49,180
boil or freeze so why is that so here's

292
00:11:53,220 --> 00:11:51,010
a plot with temperature on the

293
00:11:55,470 --> 00:11:53,230
horizontal axis pressure on the vertical

294
00:11:57,510 --> 00:11:55,480
axis and this is a phase diagram so at

295
00:11:59,400 --> 00:11:57,520
any particular pressure temperature pair

296
00:12:03,060 --> 00:11:59,410
water will be in one of three phases

297
00:12:05,160 --> 00:12:03,070
right solid liquid or vapor at the earth

298
00:12:07,500 --> 00:12:05,170
which has an atmosphere pressure of one

299
00:12:10,050 --> 00:12:07,510
atmosphere and this temperature range

300
00:12:12,200 --> 00:12:10,060
indicated by the yellow line water can

301
00:12:16,520 --> 00:12:12,210
be in all three phases solid liquid or

302
00:12:19,560 --> 00:12:16,530
gas but at Mars which is that these

303
00:12:21,990 --> 00:12:19,570
Arnold's head exploding pressures of

304
00:12:24,330 --> 00:12:22,000
what point zero zero six atmospheres

305
00:12:27,300 --> 00:12:24,340
right you're down below the triple point

306
00:12:29,520 --> 00:12:27,310
of water so you can never have liquid

307
00:12:31,980 --> 00:12:29,530
water on the surface of Mars I'm you can

308
00:12:34,320 --> 00:12:31,990
only have solid or vapor now this is

309
00:12:35,790 --> 00:12:34,330
water in its pure form right you can

310
00:12:38,520 --> 00:12:35,800
like totally throw a whole bunch of

311
00:12:40,590 --> 00:12:38,530
chloride salts in there and maybe get

312
00:12:43,110 --> 00:12:40,600
water to stay liquid right just like

313
00:12:45,300 --> 00:12:43,120

when they put de-icers on the road the

314
00:12:49,290 --> 00:12:45,310
water stays liquid instead of freezing

315
00:12:51,120 --> 00:12:49,300
and killing everybody all right so

316
00:12:53,300 --> 00:12:51,130
there's lots of evidence for past water

317
00:12:56,430 --> 00:12:53,310
even if they can't be liquid water on

318
00:12:58,020 --> 00:12:56,440
Mars today there's shape evidence or

319
00:13:01,580 --> 00:12:58,030
morphological evidence in the form of

320
00:13:03,960 --> 00:13:01,590
these river deltas all over Mars you see

321
00:13:06,600 --> 00:13:03,970
shapes which can only be formed by water

322
00:13:09,240 --> 00:13:06,610
which was flowing it's still an open

323
00:13:11,610 --> 00:13:09,250
question as to how much water was

324
00:13:13,830 --> 00:13:11,620
required to create these features some

325
00:13:16,380 --> 00:13:13,840
people think that Mars was very cold and

326
00:13:18,130 --> 00:13:16,390
dry even when it was warm and wet right

327
00:13:20,620 --> 00:13:18,140
it was cold and dry in comparison

328
00:13:23,470 --> 00:13:20,630
the earth we can also look at

329
00:13:25,240 --> 00:13:23,480
mineralogical evidence so the color is

330
00:13:27,040 --> 00:13:25,250
in this image which is of jezero crater

331
00:13:30,480 --> 00:13:27,050
I believe it was one of the potential

332
00:13:32,500 --> 00:13:30,490
landing sites for the Curiosity rover

333
00:13:34,690 --> 00:13:32,510
eventually they chose gale crater over

334
00:13:35,980 --> 00:13:34,700
jezero but the reason why it was even

335
00:13:38,890 --> 00:13:35,990
being considered is because of all this

336
00:13:41,560 --> 00:13:38,900
blue and green which is a mineralogical

337
00:13:43,540 --> 00:13:41,570
indication that there are clays there

338
00:13:46,330 --> 00:13:43,550

and these clays on which are called

339
00:13:48,520 --> 00:13:46,340
phyllosilicates because they have silica

340
00:13:52,060 --> 00:13:48,530
and because they're layered like phyllo

341
00:13:54,880 --> 00:13:52,070
dough these clays require water in order

342
00:13:57,280 --> 00:13:54,890
to form so if you have water and you

343
00:13:59,080 --> 00:13:57,290
have silicates you can make a clay make

344
00:14:01,690 --> 00:13:59,090
a phyllosilicate clay and that's what

345
00:14:04,930 --> 00:14:01,700
we're seeing from space here via

346
00:14:08,230 --> 00:14:04,940
infrared spectroscopy at least that's

347
00:14:10,600 --> 00:14:08,240
what we think we're seeing you can never

348
00:14:13,600 --> 00:14:10,610
really be sure until you go there and

349
00:14:15,820 --> 00:14:13,610
pick up a sample and do detailed

350
00:14:18,070 --> 00:14:15,830
mineralogy so we'll have a talk this

351
00:14:19,780 --> 00:14:18,080
afternoon about cerro negro and

352
00:14:21,970 --> 00:14:19,790
Nicaragua which is one of the youngest

353
00:14:26,370 --> 00:14:21,980
volcanoes on the earth Emma when did it

354
00:14:30,820 --> 00:14:28,810
1850 right so there's a historical

355
00:14:32,440 --> 00:14:30,830
record of every single eruption that

356
00:14:33,640 --> 00:14:32,450
Cerro Negro has experienced which means

357
00:14:35,710 --> 00:14:33,650
if you go there and you're like look at

358
00:14:38,200 --> 00:14:35,720
this interesting rock you can like look

359
00:14:40,480 --> 00:14:38,210
up in the historical Almanac exactly

360
00:14:43,140 --> 00:14:40,490
when that rock was in place right

361
00:14:45,040 --> 00:14:43,150
exactly when it happened so we have a

362
00:14:47,050 --> 00:14:45,050
historical record of the formation

363
00:14:53,190 --> 00:14:47,060

environment for every rock that you

364
00:14:56,860 --> 00:14:55,600
for every rock that you might find at

365
00:14:58,330 --> 00:14:56,870
Cerro Negro so you can actually go there

366
00:14:59,890 --> 00:14:58,340
and Emmas going to talk about her work

367
00:15:02,590 --> 00:14:59,900
where she went there with a portable

368
00:15:04,060 --> 00:15:02,600
spectrometer infrared spectrometer put

369
00:15:06,190 --> 00:15:04,070
it right up next to the rock and then

370
00:15:08,350 --> 00:15:06,200
brought those rocks back for analysis so

371
00:15:10,600 --> 00:15:08,360
we can actually do a detailed comparison

372
00:15:11,920 --> 00:15:10,610
of what you might see on the ground to

373
00:15:13,450 --> 00:15:11,930
what you do see from space will have

374
00:15:16,480 --> 00:15:13,460
several other talks about that as well

375
00:15:17,860 --> 00:15:16,490
um so here's what you do here's what you

376
00:15:20,830 --> 00:15:17,870
see from space right here's some more

377
00:15:24,070 --> 00:15:20,840
blue stuff right that blue stuff here is

378
00:15:25,510 --> 00:15:24,080
this iron magnesium smectite clay right

379
00:15:27,400 --> 00:15:25,520
so whenever you hear the word smectite

380
00:15:28,660 --> 00:15:27,410
you should just think clay whenever hear

381
00:15:31,000 --> 00:15:28,670
the word clay you should think water

382
00:15:31,630 --> 00:15:31,010
right so this the idea here is that this

383
00:15:33,910 --> 00:15:31,640
particular

384
00:15:35,650 --> 00:15:33,920
band structure which we think we're

385
00:15:38,820 --> 00:15:35,660
observing based on the fit to the

386
00:15:43,360 --> 00:15:38,830
spacecraft observe spectra is

387
00:15:47,830 --> 00:15:43,370
characteristic of clay so you have this

388
00:15:49,720 --> 00:15:47,840

lava rich unit up here this ultramafic

389
00:15:52,720 --> 00:15:49,730
unit which is basically just love and it

390
00:15:55,000 --> 00:15:52,730
came straight out of a volcano later on

391
00:16:00,310 --> 00:15:55,010
water can flow through and alter that

392
00:16:01,720 --> 00:16:00,320
lava to make the smectite clays so there

393
00:16:03,610 --> 00:16:01,730
are a lot of images like this in the

394
00:16:05,620 --> 00:16:03,620
literature on Mars I'm Bethenny ailment

395
00:16:06,820 --> 00:16:05,630
is a specialist in this sort of thing so

396
00:16:09,900 --> 00:16:06,830
if you've ever read a paper of hers

397
00:16:13,930 --> 00:16:09,910
she's got lots of these images showing

398
00:16:15,430 --> 00:16:13,940
orbital spectra of Mars that say where

399
00:16:18,280 --> 00:16:15,440
the water is but you should always keep

400
00:16:20,260 --> 00:16:18,290
in mind that we need to know what it

401
00:16:22,120 --> 00:16:20,270
looked like what it looks like on the

402
00:16:23,680 --> 00:16:22,130
ground one way that we can tell what it

403
00:16:31,230 --> 00:16:23,690
looks like on the ground is with these

404
00:16:35,740 --> 00:16:33,550
on to Antarctica and they bring their

405
00:16:37,000 --> 00:16:35,750
baseball mitts and they catch meteorites

406
00:16:40,030 --> 00:16:37,010
as they come in right because it's very

407
00:16:41,980 --> 00:16:40,040
wide and flat it's very white so you can

408
00:16:43,300 --> 00:16:41,990
see the meteorites coming and you can

409
00:16:46,720 --> 00:16:43,310
actually go and catch them before they

410
00:16:48,070 --> 00:16:46,730
ever hit the ground so this is this is a

411
00:16:51,190 --> 00:16:48,080
story they tell what they actually do is

412
00:16:54,160 --> 00:16:51,200
they the meteorites land in Antarctica

413
00:16:56,770 --> 00:16:54,170

there's kilometers of ice above any

414
00:16:59,110 --> 00:16:56,780
rocks that came from Earth and then

415
00:17:00,880 --> 00:16:59,120
there's some rocks on top and so if you

416
00:17:04,270 --> 00:17:00,890
see rocks on top of those kilometers of

417
00:17:07,150 --> 00:17:04,280
ice probably they came from space and in

418
00:17:09,040 --> 00:17:07,160
addition they go to particular regions

419
00:17:12,640 --> 00:17:09,050
of Antarctica where the ice has flowed

420
00:17:14,890 --> 00:17:12,650
and been brought up to the surface so

421
00:17:16,510 --> 00:17:14,900
that you get a collection of a very wide

422
00:17:20,170 --> 00:17:16,520
area where the meteorites may have

423
00:17:21,610 --> 00:17:20,180
fallen so they go there they they stay

424
00:17:25,390 --> 00:17:21,620
in tents which are specifically designed

425
00:17:27,579 --> 00:17:25,400
to explode if the weather gets bad

426
00:17:28,780 --> 00:17:27,589
enough so that it doesn't collapse on

427
00:17:30,130 --> 00:17:28,790
you right because the worst thing would

428
00:17:31,990 --> 00:17:30,140
be if the weather gets really bad then

429
00:17:34,120 --> 00:17:32,000
you're like impaled on your tent poles

430
00:17:36,430 --> 00:17:34,130
right so these are like Scott tents

431
00:17:38,400 --> 00:17:36,440
where if the wind gets fast enough that

432
00:17:41,470 --> 00:17:38,410
top will literally blow off of the tent

433
00:17:44,920 --> 00:17:41,480
and they eat like nothing but frozen

434
00:17:45,549 --> 00:17:44,930
steak for months and every day they get

435
00:17:49,899 --> 00:17:45,559
out and

436
00:17:51,519 --> 00:17:49,909
walk like 10 meters away from every

437
00:17:54,489 --> 00:17:51,529
other person in the expedition across

438
00:18:00,399 --> 00:17:54,499

the ice and they look for rocks on top

439
00:18:02,289 --> 00:18:00,409
of the ice so this is the this was found

440
00:18:04,749 --> 00:18:02,299
in the Allen Hills region of Antarctica

441
00:18:06,610 --> 00:18:04,759
in 1984 and it was considered the first

442
00:18:08,769 --> 00:18:06,620
most interesting meteorite they found in

443
00:18:11,320 --> 00:18:08,779
that year because inside this meteorite

444
00:18:12,850 --> 00:18:11,330
or trapped bubbles of gas which exactly

445
00:18:14,850 --> 00:18:12,860
matched the composition of the Martian

446
00:18:21,070 --> 00:18:14,860
atmosphere so this is a piece of Mars

447
00:18:23,350 --> 00:18:21,080
now I have to log in again this came

448
00:18:24,730 --> 00:18:23,360
from Mars we can tell from multiple

449
00:18:26,259 --> 00:18:24,740
lines of evidence not just the bubbles

450
00:18:28,720 --> 00:18:26,269
of gas which are trapped inside it and

451
00:18:30,639 --> 00:18:28,730
so if you're really very very impressive

452
00:18:32,859 --> 00:18:30,649
you can write to NASA and say please

453
00:18:36,970 --> 00:18:32,869
send me a piece of Mars I would like to

454
00:18:39,609 --> 00:18:36,980
do science on it and in the 90s this

455
00:18:42,070 --> 00:18:39,619
meteorite was the subject of much public

456
00:18:43,869 --> 00:18:42,080
fascination because at least one

457
00:18:47,609 --> 00:18:43,879
scientist became convinced that they

458
00:18:50,409 --> 00:18:47,619
were found fossil life in this meteorite

459
00:18:51,460 --> 00:18:50,419
and there were three independent lines

460
00:18:53,230 --> 00:18:51,470
of evidence presented in the original

461
00:18:54,519 --> 00:18:53,240
paper problem is that when you're

462
00:18:56,409 --> 00:18:54,529
talking about finding life on another

463
00:18:58,749 --> 00:18:56,419

planet even three independent lines of

464
00:19:01,239 --> 00:18:58,759
evidence is not enough and subsequently

465
00:19:04,509 --> 00:19:01,249
I believe all three have been separately

466
00:19:09,460 --> 00:19:04,519
shown to be capable of being produced by

467
00:19:13,629 --> 00:19:09,470
abiotic means so I but does anybody

468
00:19:20,169 --> 00:19:13,639
remember the name of the guy Chris McKay

469
00:19:22,779 --> 00:19:20,179
um so he he was conceived McKay was was

470
00:19:26,200 --> 00:19:22,789
uh he believed yeah he believed until

471
00:19:28,749 --> 00:19:26,210
his death that he had found life on Mars

472
00:19:30,070 --> 00:19:28,759
in this meteorite um but you always have

473
00:19:31,299 --> 00:19:30,080
to wonder right because I mean who knows

474
00:19:33,340 --> 00:19:31,309
how long this was sitting there before

475
00:19:35,919 --> 00:19:33,350
nineteen eighty-four right maybe it was

476
00:19:38,169 --> 00:19:35,929
Antarctic life that like got in there

477
00:19:41,590 --> 00:19:38,179
and left those fossils right a million

478
00:19:43,299 --> 00:19:41,600
years ago so we'll have a talk about

479
00:19:45,700 --> 00:19:43,309
differentiating between Antarctic

480
00:19:46,840 --> 00:19:45,710
weathering and meteorites and what may

481
00:19:49,419 --> 00:19:46,850
have been the original formation

482
00:19:52,749 --> 00:19:49,429
environment on Mars and you can tell a

483
00:19:54,450 --> 00:19:52,759
lot from the mineralogy and petrology of

484
00:19:56,499 --> 00:19:54,460
these rocks where they came from on Mars

485
00:19:58,029 --> 00:19:56,509
and I think actually this one turns out

486
00:19:58,670 --> 00:19:58,039
to be a little bit weird and comparison

487
00:20:05,300 --> 00:19:58,680
to the other more

488
00:20:06,950 --> 00:20:05,310

meteorites that all right so questions

489
00:20:08,500 --> 00:20:06,960
worth asking right what alternate

490
00:20:11,450 --> 00:20:08,510
formation mechanisms did you investigate

491
00:20:13,460 --> 00:20:11,460
M is going to talk this afternoon about

492
00:20:16,850 --> 00:20:13,470
her work in sierra negra were actually

493
00:20:19,060 --> 00:20:16,860
they find phyllosilicate clays in this

494
00:20:21,830 --> 00:20:19,070
very definitely volcanic environment

495
00:20:23,570 --> 00:20:21,840
right so there has been a cuius

496
00:20:25,160 --> 00:20:23,580
alteration there but not of the kind

497
00:20:27,260 --> 00:20:25,170
that we would expect in like a riverbed

498
00:20:29,330 --> 00:20:27,270
right so when people see phyllosilicates

499
00:20:30,800 --> 00:20:29,340
on Mars maybe they were formed in a

500
00:20:32,750 --> 00:20:30,810
different way than we would expect maybe

501
00:20:34,310 --> 00:20:32,760
we were fooling ourselves that there's a

502
00:20:36,380 --> 00:20:34,320
lot of water there so you can always ask

503
00:20:38,210 --> 00:20:36,390
what alternate formation mechanism best

504
00:20:39,770 --> 00:20:38,220
agay tanned then all of these studies of

505
00:20:41,270 --> 00:20:39,780
analog environments are always missing

506
00:20:43,730 --> 00:20:41,280
something right because they're on earth

507
00:20:45,260 --> 00:20:43,740
they're not on the other planet so what

508
00:20:47,450 --> 00:20:45,270
is it it's missing what is it that's

509
00:20:50,540 --> 00:20:47,460
wrong about your analog environment what

510
00:20:52,880 --> 00:20:50,550
didn't you consider okay so on

511
00:20:54,410 --> 00:20:52,890
particular analog environment that a lot

512
00:20:57,290 --> 00:20:54,420
of people study are these Antarctic Dry

513
00:21:00,020 --> 00:20:57,300

Valleys so they are right here in

514
00:21:02,630 --> 00:21:00,030
Antarctica these dry valleys and that's

515
00:21:04,190 --> 00:21:02,640
also so if you zoom in on a map of

516
00:21:05,960 --> 00:21:04,200
Antarctica not all of Antarctica is

517
00:21:08,900 --> 00:21:05,970
completely covered in ice parts of it

518
00:21:11,860 --> 00:21:08,910
are very dry and don't experience any

519
00:21:16,460 --> 00:21:11,870
snow over the course of a typical year

520
00:21:17,750 --> 00:21:16,470
so people go to these valleys they're

521
00:21:20,000 --> 00:21:17,760
actually like right here in this

522
00:21:21,620 --> 00:21:20,010
background image of the earth people go

523
00:21:23,120 --> 00:21:21,630
to these valleys and they camp out and

524
00:21:25,310 --> 00:21:23,130
again these tents which are designed to

525
00:21:26,990 --> 00:21:25,320
explode if the weather gets too bad and

526
00:21:29,030 --> 00:21:27,000
these valleys are incredibly well

527
00:21:31,790 --> 00:21:29,040
protected in terms of what you are

528
00:21:33,590 --> 00:21:31,800
required to do in order to go there the

529
00:21:37,040 --> 00:21:33,600
people who go there have to bottle their

530
00:21:38,480 --> 00:21:37,050
urine and take their urine out because

531
00:21:41,210 --> 00:21:38,490
it might contaminate the local

532
00:21:43,340 --> 00:21:41,220
environment and in particular the

533
00:21:45,760 --> 00:21:43,350
microbes that live in this lake down

534
00:21:49,070 --> 00:21:45,770
here wouldn't necessarily like

535
00:21:50,630 --> 00:21:49,080
contaminants getting in there I'm so

536
00:21:51,950 --> 00:21:50,640
these analog environments are really

537
00:21:53,800 --> 00:21:51,960
great for a variety of reasons they're

538
00:21:56,120 --> 00:21:53,810

the coldest driest places on the earth

539
00:21:58,040 --> 00:21:56,130
there's still a heck of a lot warmer and

540
00:22:00,350 --> 00:21:58,050
wetter than a typical place on Mars but

541
00:22:02,030 --> 00:22:00,360
they're the closest that you can get and

542
00:22:05,770 --> 00:22:02,040
occasionally you see things like this

543
00:22:09,440 --> 00:22:05,780
right here forming in these valleys and

544
00:22:11,570 --> 00:22:09,450
these are formed when water flows in the

545
00:22:12,980 --> 00:22:11,580
valley and darkens the soil periodically

546
00:22:15,190 --> 00:22:12,990
we also see these

547
00:22:18,080 --> 00:22:15,200
mars we call them slope streaks there

548
00:22:20,540 --> 00:22:18,090
and they're persistent throughout the

549
00:22:22,280 --> 00:22:20,550
high latitudes on Mars there I believe

550
00:22:24,590 --> 00:22:22,290
they're also seasonal and they've been

551
00:22:27,230 --> 00:22:24,600
observed not only to exist but also to

552
00:22:28,280 --> 00:22:27,240
change over the course of a reasonable

553
00:22:31,100 --> 00:22:28,290
time spent so you'll see them like

554
00:22:33,140 --> 00:22:31,110
expand and propagate there are a lot of

555
00:22:35,299 --> 00:22:33,150
proposed formation mechanisms for these

556
00:22:36,980 --> 00:22:35,309
some of which do not require water which

557
00:22:38,510 --> 00:22:36,990
gets back to that question right what

558
00:22:40,520 --> 00:22:38,520
alternate formation mechanisms might

559
00:22:43,100 --> 00:22:40,530
there be just because this thing we see

560
00:22:45,460 --> 00:22:43,110
on the earth requires water doesn't mean

561
00:22:48,620 --> 00:22:45,470
that these things that we see on Mars

562
00:22:50,630 --> 00:22:48,630
necessarily require water I'm still have

563
00:22:53,240 --> 00:22:50,640

a talk about slope streaks this

564
00:22:54,770 --> 00:22:53,250
afternoon another thing that you see in

565
00:22:59,299 --> 00:22:54,780
these dry valleys are these really brine

566
00:23:01,460 --> 00:22:59,309
rich ponds and if water exists on Mars

567
00:23:05,530 --> 00:23:01,470
today is almost certainly in the form of

568
00:23:08,419 --> 00:23:05,540
brians and one interesting thing that

569
00:23:11,090 --> 00:23:08,429
was recently discovered in 2006 by the

570
00:23:15,530 --> 00:23:11,100
Phoenix lander are perchlorates or

571
00:23:17,090 --> 00:23:15,540
chlorine salts that were found on the

572
00:23:18,470 --> 00:23:17,100
surface of Mars they're completely onyx

573
00:23:20,960 --> 00:23:18,480
they're completely unexpected when they

574
00:23:22,970 --> 00:23:20,970
were found so the Phoenix lander

575
00:23:26,480 --> 00:23:22,980
contained a wet chemistry or a wet soil

576
00:23:28,280 --> 00:23:26,490
analyzer that went to the North Pole of

577
00:23:30,919 --> 00:23:28,290
Mars scooped up a little bit of soil and

578
00:23:33,440 --> 00:23:30,929
looked at what was in that soil found

579
00:23:35,630 --> 00:23:33,450
these perchlorate salts that may explain

580
00:23:38,930 --> 00:23:35,640
one of the mysteries of the early Viking

581
00:23:40,730 --> 00:23:38,940
landers as to why the life detection

582
00:23:43,330 --> 00:23:40,740
experiments at two positives and two

583
00:23:47,390 --> 00:23:43,340
negatives but these perchlorate salts

584
00:23:49,730 --> 00:23:47,400
were found and these are actually really

585
00:23:52,910 --> 00:23:49,740
good at acting as antifreeze for water

586
00:23:55,580 --> 00:23:52,920
so they'll absorb water out of the

587
00:23:57,200 --> 00:23:55,590
atmosphere and create a brine even at

588
00:24:00,500 --> 00:23:57,210

the low water concentrations that you

589
00:24:02,330 --> 00:24:00,510
see in the atmosphere of Mars one

590
00:24:04,040 --> 00:24:02,340
proposed formation mechanism is that

591
00:24:06,080 --> 00:24:04,050
they're produced by UV light interacting

592
00:24:08,210 --> 00:24:06,090
with chloride rich soils so there's a

593
00:24:10,790 --> 00:24:08,220
Death Valley analogue where if you leave

594
00:24:13,850 --> 00:24:10,800
a lot of chloride rich soil out for very

595
00:24:16,790 --> 00:24:13,860
long time under UV light you can maybe

596
00:24:19,850 --> 00:24:16,800
get these perchlorates to form this is a

597
00:24:21,950 --> 00:24:19,860
picture of a trench that was dug by the

598
00:24:23,390 --> 00:24:21,960
Phoenix lander I like to tell my

599
00:24:26,630 --> 00:24:23,400
students when I teach an intro class

600
00:24:28,070 --> 00:24:26,640
that planetary science is still so new

601
00:24:29,870 --> 00:24:28,080
that if you send a shovel to another

602
00:24:34,910 --> 00:24:29,880
planet you're doing literally

603
00:24:36,710 --> 00:24:34,920
groundbreaking science so being excited

604
00:24:39,350 --> 00:24:36,720
this little scoop that scooped out a

605
00:24:41,450 --> 00:24:39,360
little bit of soil and then it saw these

606
00:24:43,490 --> 00:24:41,460
white spots disappear over the course of

607
00:24:47,000 --> 00:24:43,500
several days the interpretation was that

608
00:24:49,130 --> 00:24:47,010
there's subsurface ice all throughout

609
00:24:53,090 --> 00:24:49,140
the north and latitudes of Mars this is

610
00:24:56,180 --> 00:24:53,100
consistent with observations of neutrons

611
00:24:57,710 --> 00:24:56,190
which are made from orbit there's the

612
00:24:59,870 --> 00:24:57,720
subsurface ice mantle tends to absorb

613
00:25:02,900 --> 00:24:59,880

neutrons quite well so there's sort of

614
00:25:05,210 --> 00:25:02,910
gaps in what we would expect in these

615
00:25:12,020 --> 00:25:05,220
northerly latitudes I really got to fix

616
00:25:14,810 --> 00:25:12,030
this login problem I suppose I could

617
00:25:16,880 --> 00:25:14,820
plug in I'm really close to the end so

618
00:25:19,520 --> 00:25:16,890
I'm just going to keep going all right

619
00:25:21,290 --> 00:25:19,530
so questions worth asking right whenever

620
00:25:24,140 --> 00:25:21,300
you talk about an analog environment or

621
00:25:26,540 --> 00:25:24,150
any of these brines or slope streaks you

622
00:25:28,160 --> 00:25:26,550
could ask could any microbe could any

623
00:25:29,420 --> 00:25:28,170
known microbes survive in the

624
00:25:31,870 --> 00:25:29,430
environment that you're talking about

625
00:25:34,370 --> 00:25:31,880
and there are people working on this if

626
00:25:36,500 --> 00:25:34,380
nothing on earth could survive in that

627
00:25:37,850 --> 00:25:36,510
environment well then you have a little

628
00:25:39,410 --> 00:25:37,860
bit more of a case to make about why

629
00:25:42,800 --> 00:25:39,420
this might be Astro biologically

630
00:25:45,050 --> 00:25:42,810
relevant and then how long if there was

631
00:25:47,450 --> 00:25:45,060
life earlier on when conditions were

632
00:25:49,610 --> 00:25:47,460
maybe a little bit better but things got

633
00:25:52,310 --> 00:25:49,620
worse how long would you preserve any

634
00:25:54,380 --> 00:25:52,320
fossil life are these slope streaks a

635
00:25:56,390 --> 00:25:54,390
good place to look for currently extent

636
00:25:58,760 --> 00:25:56,400
microbes right we'll you'll find

637
00:26:00,470 --> 00:25:58,770
microfossils or like little fish fossils

638
00:26:04,760 --> 00:26:00,480

and these slope streaks when the water

639
00:26:06,710 --> 00:26:04,770
burst out it's a worthwhile question to

640
00:26:08,000 --> 00:26:06,720
ask because if you're making a case that

641
00:26:11,450 --> 00:26:08,010
this is an astro biologically

642
00:26:13,910 --> 00:26:11,460
interesting phenomenon we got to talk

643
00:26:16,370 --> 00:26:13,920
about whether or not life could exist or

644
00:26:19,870 --> 00:26:16,380
whether we could see evidence of fossil

645
00:26:22,040 --> 00:26:19,880
life alright so that's all that I have

646
00:26:23,870 --> 00:26:22,050
we're going to have I think that I've

647
00:26:26,630 --> 00:26:23,880
covered everybody's talks that I was

648
00:26:29,150 --> 00:26:26,640
supposed to cover if you have questions

649
00:26:32,330 --> 00:26:29,160
you can either ask me and if i don't

650
00:26:33,740 --> 00:26:32,340
know i will tell you to ask the people

651
00:26:35,120 --> 00:26:33,750
who actually know which is people who

652
00:26:43,680 --> 00:26:35,130
are presenting in the afternoon thanks

653
00:26:43,690 --> 00:27:18,480
question

654
00:27:21,870 --> 00:27:20,520
okay yeah so I'm going to repeat the

655
00:27:24,630 --> 00:27:21,880
question for the benefit of people who

656
00:27:26,220 --> 00:27:24,640
may be watching online so the question

657
00:27:28,260 --> 00:27:26,230
is whether if there is a global

658
00:27:30,390 --> 00:27:28,270
subsurface ice layer or if there is a

659
00:27:33,120 --> 00:27:30,400
subsurface ice layer on Mars what would

660
00:27:36,330 --> 00:27:33,130
be the implications for the stuff that's

661
00:27:37,890 --> 00:27:36,340
above that ice layer in particular when

662
00:27:39,480 --> 00:27:37,900
we talk about Antarctica we have this

663
00:27:42,630 --> 00:27:39,490

thick ice layer the stuff on top is

664
00:27:45,600 --> 00:27:42,640
interpreted as having come from space so

665
00:27:47,520 --> 00:27:45,610
one thing is on Mars on the ice layer is

666
00:27:50,820 --> 00:27:47,530
not necessarily global I misspoke when I

667
00:27:52,380 --> 00:27:50,830
said global earlier so it's mostly in

668
00:27:54,690 --> 00:27:52,390
the northerly latitude so north of about

669
00:27:58,980 --> 00:27:54,700
60 degrees or south of about 60 degrees

670
00:28:01,410 --> 00:27:58,990
latitude and I I'm not entirely sure but

671
00:28:04,590 --> 00:28:01,420
I believe that the idea here is that

672
00:28:06,240 --> 00:28:04,600
very early on in Mars history the water

673
00:28:08,310 --> 00:28:06,250
sort of settled out in the permafrost

674
00:28:10,560 --> 00:28:08,320
layer like very like we have in the

675
00:28:12,780 --> 00:28:10,570
northerly latitudes on the earth so once

676
00:28:14,850 --> 00:28:12,790
Mars gets cold enough the water ice is

677
00:28:16,560 --> 00:28:14,860
stable not on the surface but in the

678
00:28:18,750 --> 00:28:16,570
subsurface right if it's on the surface

679
00:28:21,390 --> 00:28:18,760
it'll vaporize and deposit elsewhere

680
00:28:24,870 --> 00:28:21,400
maybe later get buried so you could get

681
00:28:28,980 --> 00:28:24,880
like layers of soil and ice and soil and

682
00:28:30,990 --> 00:28:28,990
ice and I mean as far as I know Phoenix

683
00:28:32,730 --> 00:28:31,000
Doug like a couple trenches and then

684
00:28:35,880 --> 00:28:32,740
that was it right it was buried under

685
00:28:39,110 --> 00:28:35,890
the seasonal co2 frost which is

686
00:28:41,190 --> 00:28:39,120
deposited every winter on Mars and then

687
00:28:42,810 --> 00:28:41,200
so if you want you could send a bigger

688
00:28:45,360 --> 00:28:42,820

shovel and that would be like a

689
00:28:48,330 --> 00:28:45,370
geologist dream send a bigger shovel to

690
00:28:51,360 --> 00:28:48,340
Mars really scoop out some stuff and see

691
00:28:53,940 --> 00:28:51,370
if we can like see the strata you see it

692
00:28:57,030 --> 00:28:53,950
a lot in road cuts on the earth right

693
00:28:59,310 --> 00:28:57,040
when you cut through a ridge and you can

694
00:29:01,320 --> 00:28:59,320
see the layers right geologists would

695
00:29:02,970 --> 00:29:01,330
love to do that on Mars right build it

696
00:29:10,380 --> 00:29:02,980
build a highway on Mars and then drive