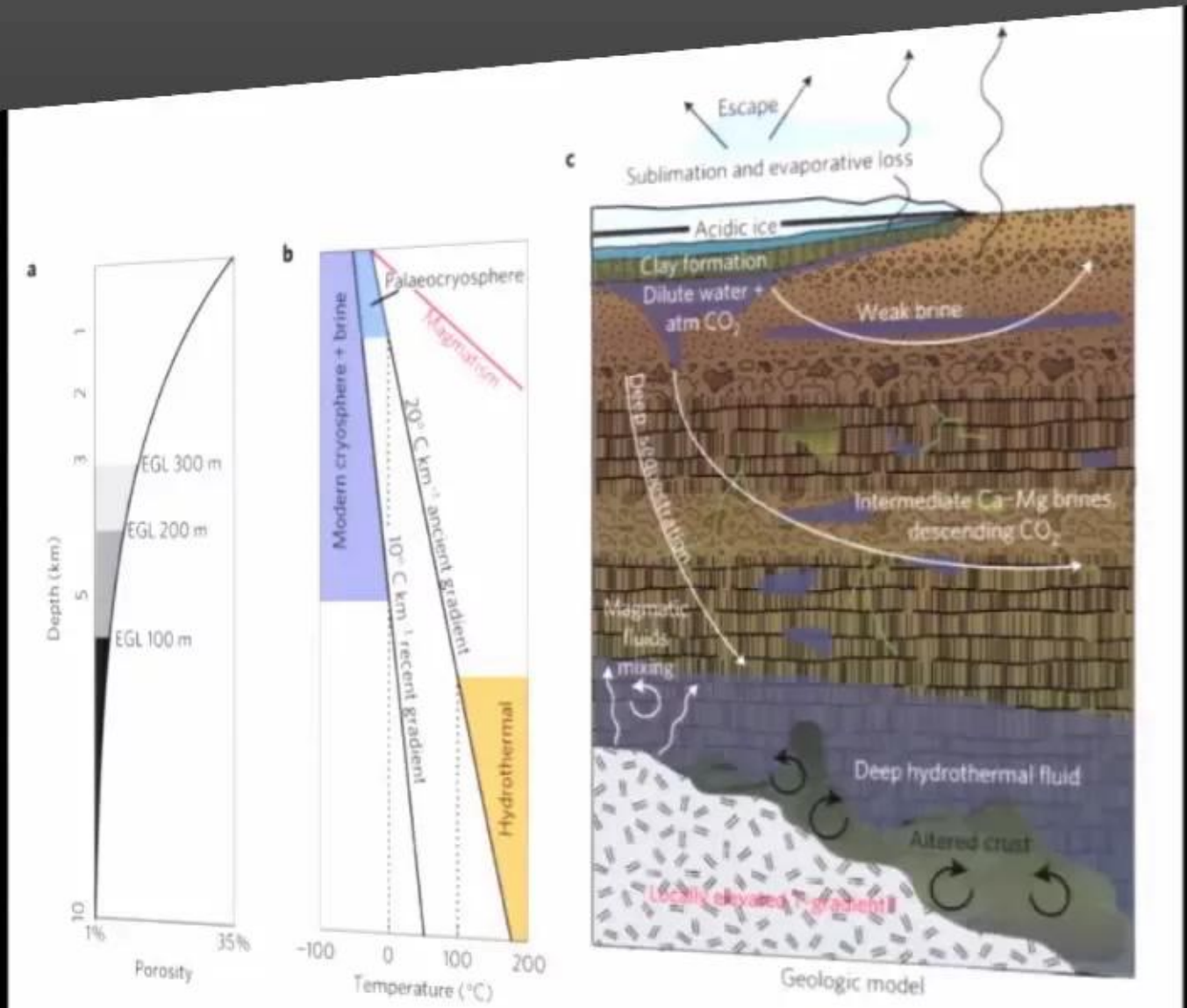

Michalski et al. 2013
(*Nature Geoscience*)

1
00:00:11,200 --> 00:00:07,690
thanks everybody for sticking around

2
00:00:14,080 --> 00:00:11,210
after lunch so it's kind of a weird

3
00:00:16,570 --> 00:00:14,090
juxtaposition and I will readily admit

4
00:00:18,100 --> 00:00:16,580
that I know very little about Mars so

5
00:00:19,570 --> 00:00:18,110
the first part of this talk is mostly

6
00:00:21,220 --> 00:00:19,580
going to be about here's what's

7
00:00:23,170 --> 00:00:21,230
interesting about Mars it may not

8
00:00:25,569 --> 00:00:23,180
actually deal with some of the talks but

9
00:00:27,339 --> 00:00:25,579
and you know interesting information you

10
00:00:29,830 --> 00:00:27,349
can have as you can see this is a

11
00:00:31,870 --> 00:00:29,840
picture of the limb of Mars so we've got

12
00:00:34,110 --> 00:00:31,880
both of n picture of the atmosphere

13
00:00:37,090 --> 00:00:34,120

involved there and then solid surface

14
00:00:40,450 --> 00:00:37,100
and craters which we will hear a little

15
00:00:43,330 --> 00:00:40,460
bit more about later today so first I

16
00:00:47,230 --> 00:00:43,340
want to introduce the major players we

17
00:00:51,250 --> 00:00:47,240
have the Earth and Mars just give you

18
00:00:53,260 --> 00:00:51,260
guys a little bit of particulars the

19
00:00:56,500 --> 00:00:53,270
Martian day is a little longer than the

20
00:00:59,050 --> 00:00:56,510
earth day it takes about six hundred in

21
00:01:01,990 --> 00:00:59,060
some days to get around the Sun those

22
00:01:05,229 --> 00:01:02,000
are Martian days by the way and it

23
00:01:07,499 --> 00:01:05,239
weighs know about a tenth of the mass of

24
00:01:11,890 --> 00:01:07,509
the earth and it's about half the size

25
00:01:13,780 --> 00:01:11,900
so it's cold it's dry the surface

26
00:01:16,810 --> 00:01:13,790
temperature actually varies by more than

27
00:01:20,649 --> 00:01:16,820
a factor of two goes from 130 k at its

28
00:01:24,430 --> 00:01:20,659
lease point2 about 310 k and the surface

29
00:01:28,420 --> 00:01:24,440
pressure is actually about six millibars

30
00:01:30,580 --> 00:01:28,430
and varies from about four millibars to

31
00:01:32,700 --> 00:01:30,590
greater than eight millibars so that

32
00:01:34,990 --> 00:01:32,710
also varies by more than a factor of two

33
00:01:39,640 --> 00:01:35,000
the surface gravity is a little lower

34
00:01:42,730 --> 00:01:39,650
and clearly my slide didn't show up

35
00:01:45,219 --> 00:01:42,740
entirely but for example the Earth's

36
00:01:48,429 --> 00:01:45,229
atmosphere is made up of principally

37
00:01:52,060 --> 00:01:48,439
nitrogen and oxygen and argon with a

38
00:01:55,300 --> 00:01:52,070

little tiny bit of water and co2 whereas

39
00:01:58,870 --> 00:01:55,310
the Martian atmosphere is mostly co2 and

40
00:02:02,320 --> 00:01:58,880
nitrogen and argon and a little bit of

41
00:02:07,649 --> 00:02:02,330
oxygen and then water vapor and the

42
00:02:10,029 --> 00:02:07,659
Martian atmosphere is very very tenuous

43
00:02:12,429 --> 00:02:10,039
just to give you a little picture of

44
00:02:15,550 --> 00:02:12,439
what the earth-moon system looks like in

45
00:02:16,839 --> 00:02:15,560
perspective this is to scale because

46
00:02:18,580 --> 00:02:16,849
we're going to be talking about Mars we

47
00:02:21,720 --> 00:02:18,590
should also look at the Martian moons to

48
00:02:27,539 --> 00:02:24,070
there yeah that's right you should laugh

49
00:02:31,470 --> 00:02:27,549
if you can't see it this is Phobos and

50
00:02:34,360 --> 00:02:31,480
this is Deimos and those are to scale

51
00:02:35,830 --> 00:02:34,370
we're taking an interesting betting pool

52
00:02:37,690 --> 00:02:35,840
because Phobos is actually on a

53
00:02:41,199 --> 00:02:37,700
degrading orbit so sometime in the next

54
00:02:44,800 --> 00:02:41,209
50 million years from now not then now

55
00:02:46,630 --> 00:02:44,810
now it will eventually thank someone got

56
00:02:49,720 --> 00:02:46,640
the reference it will eventually collide

57
00:02:51,160 --> 00:02:49,730
with the solid surface of Mars so if you

58
00:02:52,479 --> 00:02:51,170
want in on the betting pool you have to

59
00:02:55,089 --> 00:02:52,489
play with some pretty big names like

60
00:02:58,869 --> 00:02:55,099
Emperor on the fourth and the cyber

61
00:02:59,699 --> 00:02:58,879
hegemony hegemony haga mom hey yeah

62
00:03:07,210 --> 00:02:59,709
there's a couple different

63
00:03:08,710 --> 00:03:07,220

pronunciations there so moving on the

64
00:03:12,369 --> 00:03:08,720
reason why you can't see it is because

65
00:03:16,479 --> 00:03:12,379
this is the size of Phobos here's

66
00:03:21,729 --> 00:03:16,489
Madison for scale so very tiny moon its

67
00:03:25,120 --> 00:03:21,739
most likely captured if we start looking

68
00:03:27,339 --> 00:03:25,130
at the solid surface of Mars we get some

69
00:03:30,030 --> 00:03:27,349
very interesting features these are the

70
00:03:34,539 --> 00:03:30,040
Northern Plains they're relatively

71
00:03:37,500 --> 00:03:34,549
crater under full whereas the southern

72
00:03:41,640 --> 00:03:37,510
portion of Mars is incredibly cratered

73
00:03:45,460 --> 00:03:41,650
one of our talks will feature the a

74
00:03:47,409 --> 00:03:45,470
Sedalia platinum Leisha I'm sorry again

75
00:03:51,400 --> 00:03:47,419
I'm not an expert on Mars or Martian

76
00:03:52,900 --> 00:03:51,410
pronunciation but it's this this plane

77
00:03:54,759 --> 00:03:52,910
right here that has a few impact

78
00:03:57,009 --> 00:03:54,769
structures that could give us some clues

79
00:03:59,949 --> 00:03:57,019
about some of the sedimentary structures

80
00:04:03,309 --> 00:03:59,959
that may underlie a lot of the surface

81
00:04:05,559 --> 00:04:03,319
of Mars and so you can still you can see

82
00:04:08,080 --> 00:04:05,569
this dichotomy where you have a fairly

83
00:04:10,689 --> 00:04:08,090
flat Northern Hemisphere and a very well

84
00:04:14,920 --> 00:04:10,699
cratered southern hemisphere and that

85
00:04:17,670 --> 00:04:14,930
dichotomy between the low-lying northern

86
00:04:21,099 --> 00:04:17,680
hemisphere and the up did or

87
00:04:23,710 --> 00:04:21,109
high-altitude southern hemisphere is

88
00:04:25,480 --> 00:04:23,720

very interesting I don't think there's

89
00:04:27,880 --> 00:04:25,490
been a very good explanation as to why

90
00:04:29,469 --> 00:04:27,890
that is there have been some suggestions

91
00:04:31,990 --> 00:04:29,479
that it could be an impact structure or

92
00:04:33,010 --> 00:04:32,000
a weird heterogeneity in the mantle

93
00:04:38,020 --> 00:04:33,020
that's

94
00:04:39,909 --> 00:04:38,030
early on its history but when someone

95
00:04:43,119 --> 00:04:39,919
solves that please let me know this is

96
00:04:44,890 --> 00:04:43,129
crazy and awesome you can see some of

97
00:04:47,350 --> 00:04:44,900
the big mountains like Olympus Mons they

98
00:04:49,330 --> 00:04:47,360
stand out in relief biggest mountain in

99
00:04:51,369 --> 00:04:49,340
the solar system including the mountains

100
00:04:55,770 --> 00:04:51,379
on Pluto which aren't very interesting

101
00:05:00,640 --> 00:04:59,230
so through the history of Mars we've had

102
00:05:03,869 --> 00:05:00,650
a number of really interesting things

103
00:05:06,249 --> 00:05:03,879
happen you've got these very large

104
00:05:08,529 --> 00:05:06,259
impacts that show up early in its

105
00:05:11,879 --> 00:05:08,539
history even prior to the noachian which

106
00:05:14,439 --> 00:05:11,889
is the oldest period of Martian history

107
00:05:16,120 --> 00:05:14,449
the magnetic field is thought to have

108
00:05:17,890 --> 00:05:16,130
shut off about four billion years ago

109
00:05:20,800 --> 00:05:17,900
that would have protected its atmosphere

110
00:05:23,230 --> 00:05:20,810
from erosion by the solar wind you've

111
00:05:25,360 --> 00:05:23,240
got large periods of volcanism

112
00:05:27,939 --> 00:05:25,370
stretching through the noachian into the

113
00:05:30,219 --> 00:05:27,949

Hesperian so from about 4 billion years

114
00:05:33,070 --> 00:05:30,229
ago to about 3 billion years ago and

115
00:05:35,140 --> 00:05:33,080
then you've got some suggestion of

116
00:05:39,219 --> 00:05:35,150
hydrothermal subsurface circulation or

117
00:05:41,640 --> 00:05:39,229
flow of water even on the surface

118
00:05:44,110 --> 00:05:41,650
potentially so you have this open system

119
00:05:45,700 --> 00:05:44,120
where you have potential surface waters

120
00:05:47,290 --> 00:05:45,710
whether or not those are long-lived

121
00:05:52,450 --> 00:05:47,300
episodes of liquid water on the surface

122
00:05:55,420 --> 00:05:52,460
is still an open question and minerals

123
00:05:57,760 --> 00:05:55,430
are complicated I won't get into them

124
00:05:59,740 --> 00:05:57,770
very much but we will have a couple of

125
00:06:06,249 --> 00:05:59,750
talks about looking at terrestre analogs

126
00:06:08,589 --> 00:06:06,259
for those this is not a big image thank

127
00:06:10,300 --> 00:06:08,599
you so another one of the talks were

128
00:06:12,249 --> 00:06:10,310
going to be getting is looking at the

129
00:06:14,290 --> 00:06:12,259
subsurface of Mars and so I wanted to

130
00:06:16,269 --> 00:06:14,300
make sure everyone was on board with

131
00:06:17,950 --> 00:06:16,279
what that might look like so for example

132
00:06:19,659 --> 00:06:17,960
early in the Martian history where it

133
00:06:21,939 --> 00:06:19,669
had a higher higher geothermal gradient

134
00:06:23,649 --> 00:06:21,949
you can see that the temperature below

135
00:06:26,350 --> 00:06:23,659
the surface gets up above freezing but

136
00:06:28,719 --> 00:06:26,360
there's still a suggestion that early in

137
00:06:30,790 --> 00:06:28,729
its history the surface was below

138
00:06:33,519 --> 00:06:30,800

freezing at least in some places which

139
00:06:36,370 --> 00:06:33,529
may have been the location for a paleo

140
00:06:38,230 --> 00:06:36,380
cryosphere so you could have potential

141
00:06:40,899 --> 00:06:38,240
living organisms in these salt brians

142
00:06:42,639 --> 00:06:40,909
close to the surface fueled by these geo

143
00:06:45,909 --> 00:06:42,649
thermal gradients nowadays things are

144
00:06:46,719 --> 00:06:45,919
not cooler so in order to get down to

145
00:06:49,119 --> 00:06:46,729
the

146
00:06:51,760 --> 00:06:49,129
freezing point you have to be about five

147
00:06:53,320 --> 00:06:51,770
kilometers death depth these are still

148
00:06:54,999 --> 00:06:53,330
purely hypothetical geo thermal

149
00:06:57,219 --> 00:06:55,009
gradients we have to actually send

150
00:07:02,920 --> 00:06:57,229
somebody there to measure these go

151
00:07:05,019 --> 00:07:02,930
geology and so this is a very sort of

152
00:07:06,820 --> 00:07:05,029
simplistic view of it and really what

153
00:07:10,899 --> 00:07:06,830
you could have is these very complex

154
00:07:14,980 --> 00:07:10,909
systems where you get penetration of for

155
00:07:16,350 --> 00:07:14,990
example brines or even liquid co2 could

156
00:07:19,659 --> 00:07:16,360
be stable in the surface or subsurface

157
00:07:20,829 --> 00:07:19,669
you could get circulation through a lot

158
00:07:24,670 --> 00:07:20,839
of different strata you could get

159
00:07:27,010 --> 00:07:24,680
mineral water co2 interactions you could

160
00:07:29,469 --> 00:07:27,020
get magnetic fluids or deep hydrothermal

161
00:07:35,889 --> 00:07:29,479
circulation again you got to send

162
00:07:39,450 --> 00:07:35,899
somebody to go drill another thing we

163
00:07:43,779 --> 00:07:39,460

may hear about today is the Gale Crater

164
00:07:46,329 --> 00:07:43,789
eponymously because of the fact that we

165
00:07:49,269 --> 00:07:46,339
put a couple of Landers in here or just

166
00:07:50,709 --> 00:07:49,279
the one I guess MSL just one you know

167
00:07:54,610 --> 00:07:50,719
they put so many Landers on the damn

168
00:07:57,100 --> 00:07:54,620
thing and it's got this suggested

169
00:07:59,589 --> 00:07:57,110
alluvial fan structure so you could have

170
00:08:01,329 --> 00:07:59,599
liquid water flowing on the surface into

171
00:08:02,980 --> 00:08:01,339
this crater which could get you some

172
00:08:09,610 --> 00:08:02,990
sedimentary minerals on the surface

173
00:08:11,409 --> 00:08:09,620
which may be easy to see now speaking of

174
00:08:15,159 --> 00:08:11,419
minerals there's been some suggestion

175
00:08:17,409 --> 00:08:15,169
that for example looking at John Kline

176
00:08:20,170 --> 00:08:17,419
with one of the Sam instruments or the

177
00:08:22,439 --> 00:08:20,180
Sam instrument i should say you get the

178
00:08:25,839 --> 00:08:22,449
presence of water carbon dioxide oxygen

179
00:08:28,689 --> 00:08:25,849
and some forms of sulfur what those

180
00:08:30,760 --> 00:08:28,699
might be still little nebulous trying to

181
00:08:32,079 --> 00:08:30,770
work out the details sulfur chemistry is

182
00:08:34,680 --> 00:08:32,089
complex we'll get back to that later

183
00:08:37,000 --> 00:08:34,690
when we talk about a different planet

184
00:08:39,069 --> 00:08:37,010
and one of the talks is going to talk

185
00:08:42,009 --> 00:08:39,079
about ala night and jerra site Allen aye

186
00:08:45,129 --> 00:08:42,019
tis the aluminum bearing sulphur mineral

187
00:08:47,949 --> 00:08:45,139
and jerra site is the iron bearing one I

188
00:08:51,840 --> 00:08:47,959

can't tell the difference hopefully

189
00:08:56,590 --> 00:08:54,129
we're going to completely switch gears

190
00:08:58,569 --> 00:08:56,600
Mars is super interesting but we have to

191
00:09:00,650 --> 00:08:58,579
talk about the other session which is

192
00:09:03,780 --> 00:09:00,660
talking about planetary atmospheres

193
00:09:07,800 --> 00:09:03,790
the going interior to the earth we have

194
00:09:09,570 --> 00:09:07,810
Venus here to scale the orbits are not

195
00:09:12,810 --> 00:09:09,580
right though so don't take that at face

196
00:09:15,660 --> 00:09:12,820
value but Venus is exceptionally warm

197
00:09:17,340 --> 00:09:15,670
again my atmospheric compositions didn't

198
00:09:22,380 --> 00:09:17,350
show up but we're going to play with it

199
00:09:25,530 --> 00:09:22,390
so the day is about 6,000 hours long and

200
00:09:28,949 --> 00:09:25,540
the year is about yeah ninety percent of

201
00:09:31,860 --> 00:09:28,959
a day so it's super slow rotating it's

202
00:09:33,960 --> 00:09:31,870
in a retrograde rotation so it's really

203
00:09:38,070 --> 00:09:33,970
weird it interacts with its atmosphere

204
00:09:41,070 --> 00:09:38,080
in crazy ways and it's about the same

205
00:09:43,949 --> 00:09:41,080
mass and radius as the earth it's often

206
00:09:48,620 --> 00:09:43,959
considered to be the earth twin if earth

207
00:09:53,430 --> 00:09:48,630
had a really hot twin and I need that

208
00:09:56,880 --> 00:09:53,440
thank you and it gets it gets a lot of

209
00:09:59,699 --> 00:09:56,890
radiation it gets nearly twice as much

210
00:10:02,760 --> 00:09:59,709
as the earth does so it's a very hot

211
00:10:05,070 --> 00:10:02,770
place it has a 90 bar surface atmosphere

212
00:10:08,640 --> 00:10:05,080
that has like 700 it's hot enough to

213
00:10:11,070 --> 00:10:08,650

melt lead it's really crazy and its

214
00:10:12,329 --> 00:10:11,080
atmosphere is mostly co2 about 90 bars

215
00:10:13,670 --> 00:10:12,339
of the stuff and there's a little bit of

216
00:10:16,860 --> 00:10:13,680
nitrogen a little bit of argon

217
00:10:19,079 --> 00:10:16,870
essentially no water there has been some

218
00:10:21,480 --> 00:10:19,089
suggestion that there chlorine is pretty

219
00:10:24,930 --> 00:10:21,490
present in its atmosphere because you

220
00:10:31,380 --> 00:10:24,940
get melting of sodium chloride which is

221
00:10:33,990 --> 00:10:31,390
just crazy and so speaking of crazy this

222
00:10:35,850 --> 00:10:34,000
is an example of some of the chemistry

223
00:10:37,829 --> 00:10:35,860
we think is happening in Venus's

224
00:10:39,680 --> 00:10:37,839
atmosphere I'm not going to go through

225
00:10:42,420 --> 00:10:39,690
this all but you can see that

226
00:10:46,050 --> 00:10:42,430
essentially we're starting with like so2

227
00:10:49,800 --> 00:10:46,060
I can't even find it here it is so2 and

228
00:10:51,480 --> 00:10:49,810
we're using esos some for example

229
00:10:52,920 --> 00:10:51,490
photochemistry is happening you're

230
00:10:54,060 --> 00:10:52,930
getting some chlorine chemistry that's

231
00:10:55,890 --> 00:10:54,070
also happening and so you get the

232
00:10:58,590 --> 00:10:55,900
exchange between these reservoirs

233
00:11:00,690 --> 00:10:58,600
between like so2 and pure self or

234
00:11:05,310 --> 00:11:00,700
species you can get some sulfur aerosols

235
00:11:07,920 --> 00:11:05,320
some complex sulfur species again like I

236
00:11:10,530 --> 00:11:07,930
don't even know what that's called but

237
00:11:12,180 --> 00:11:10,540
basically chlorine is a big part of a

238
00:11:13,800 --> 00:11:12,190

lot of the chemistry that's happening in

239
00:11:16,140 --> 00:11:13,810
Venus's atmosphere

240
00:11:19,890 --> 00:11:16,150
just to show you it a different way you

241
00:11:23,310 --> 00:11:19,900
can do a lot of emissions for example

242
00:11:24,810 --> 00:11:23,320
these are photon emissions I'm not going

243
00:11:27,450 --> 00:11:24,820
to suggest that I know what these

244
00:11:29,360 --> 00:11:27,460
symbols represent but you can see that

245
00:11:31,680 --> 00:11:29,370
the reservoirs are exchanging

246
00:11:33,960 --> 00:11:31,690
constituents so for example co2 gets

247
00:11:38,000 --> 00:11:33,970
fertilized in 20 and co and then those

248
00:11:44,760 --> 00:11:40,769
that's not at all like what's happening

249
00:11:46,860 --> 00:11:44,770
on the earth and so on the earth you can

250
00:11:49,110 --> 00:11:46,870
see here that you do get some oxygen

251
00:11:51,840 --> 00:11:49,120
production from the Potala size of co2

252
00:11:54,240 --> 00:11:51,850
but on the earth oxygen is entirely

253
00:11:56,340 --> 00:11:54,250
within the domain of biology at least in

254
00:11:59,070 --> 00:11:56,350
the present earth if we look at oxygen

255
00:12:00,810 --> 00:11:59,080
through time oxygen prior to the rise of

256
00:12:02,280 --> 00:12:00,820
oxygen at the great oxidation event

257
00:12:04,560 --> 00:12:02,290
about two and a half billion years ago

258
00:12:07,710 --> 00:12:04,570
was oxygen was very low and rose to

259
00:12:09,930 --> 00:12:07,720
between one and fifty percent of modern

260
00:12:12,450 --> 00:12:09,940
and then there was a second rise of

261
00:12:14,130 --> 00:12:12,460
oxygen about six or eight hundred

262
00:12:17,790 --> 00:12:14,140
million years ago that it rose into

263
00:12:23,010 --> 00:12:17,800

about present values if we look at

264
00:12:26,370 --> 00:12:23,020
oxygen on other planets though as an

265
00:12:28,380 --> 00:12:26,380
analogy for building out a photochemical

266
00:12:30,360 --> 00:12:28,390
framework for understanding terrestrial

267
00:12:34,500 --> 00:12:30,370
planets there's been a suggestion that

268
00:12:37,320 --> 00:12:34,510
the incident stellar illumination as a

269
00:12:38,880 --> 00:12:37,330
function of wavelength can alter the

270
00:12:40,380 --> 00:12:38,890
photochemistry and the foot of

271
00:12:42,390 --> 00:12:40,390
photochemical steady state of a

272
00:12:44,880 --> 00:12:42,400
terrestrial planetary atmosphere and so

273
00:12:46,020 --> 00:12:44,890
these are the fluxes with respect to

274
00:12:47,579 --> 00:12:46,030
wavelength and these are some of the

275
00:12:50,340 --> 00:12:47,589
relevant cross sections for example for

276
00:12:53,520 --> 00:12:50,350
dissociating co2 and oxygen and ozone

277
00:12:55,170 --> 00:12:53,530
absorption so with that I will take

278
00:13:02,430 --> 00:12:55,180
questions because I'm 30 seconds over

279
00:13:09,880 --> 00:13:07,810
questions for Sonny okay cool come on

280
00:13:12,820 --> 00:13:09,890
somebody's got to know it gotta wanted

281
00:13:23,730 --> 00:13:12,830
to know something about Mars okay right

282
00:13:26,350 --> 00:13:23,740
in the back um great talk you said there

283
00:13:30,370 --> 00:13:26,360
hypothetically hydrothermal fluids on

284
00:13:32,350 --> 00:13:30,380
Mars does anyone have any hypothesis on

285
00:13:37,450 --> 00:13:32,360
what the geochemistry of those fluids

286
00:13:40,060 --> 00:13:37,460
might be I mean so the suggested liquid

287
00:13:41,950 --> 00:13:40,070
water layer in the Martian subsurface is

288
00:13:45,880 --> 00:13:41,960

fairly deep because the geothermal

289
00:13:47,920 --> 00:13:45,890
gradient is so weak so it's really a

290
00:13:50,740 --> 00:13:47,930
question of what composition those

291
00:13:52,150 --> 00:13:50,750
liquid water layers are going to have I

292
00:13:54,010 --> 00:13:52,160
would suggest that they're going to be

293
00:13:56,710 --> 00:13:54,020
if they are liquid they're going to be

294
00:13:59,440 --> 00:13:56,720
incredibly briny so you know thirty or

295
00:14:02,980 --> 00:13:59,450
forty percent salt solutions like it

296
00:14:06,970 --> 00:14:02,990
unlike it I mean you can find some of

297
00:14:13,890 --> 00:14:06,980
those crazy brines and a lot of there's

298
00:14:17,710 --> 00:14:15,730
environments where you can get those

299
00:14:19,450 --> 00:14:17,720
Brides on the surface of the earth I

300
00:14:22,180 --> 00:14:19,460
don't know if they're great analogies

301
00:14:23,320 --> 00:14:22,190
for the subsurface of Mars because you

302
00:14:27,310 --> 00:14:23,330
also have to worry about the pressure

303
00:14:28,540 --> 00:14:27,320
that you're at I didn't suggest it but I

304
00:14:30,400 --> 00:14:28,550
mean you're at a like a million

305
00:14:33,550 --> 00:14:30,410
atmospheres at five kilometers below the

306
00:14:37,240 --> 00:14:33,560
Martian surface so it's going to be

307
00:14:47,080 --> 00:14:37,250
pretty weird like welcome to terrestrial

308
00:14:51,800 --> 00:14:49,940
I'm not as a question up Pluto just

309
00:14:53,000 --> 00:14:51,810
because people talk about Pluto is

310
00:14:54,260 --> 00:14:53,010
having an atmosphere and part of your

311
00:14:56,030 --> 00:14:54,270
talk was about planetary atmospheres

312
00:14:57,500 --> 00:14:56,040
does Pluto actually have an atmosphere

313
00:14:59,060 --> 00:14:57,510

is it more like a surface-bound

314
00:15:02,090 --> 00:14:59,070
exosphere like what's on the moon do

315
00:15:04,160 --> 00:15:02,100
you've any idea um I think that I mean

316
00:15:07,720 --> 00:15:04,170
the the classical idea was that it was a

317
00:15:11,480 --> 00:15:07,730
surface pond exosphere but one of the I

318
00:15:14,300 --> 00:15:11,490
think that that's still pretty commonly

319
00:15:16,040 --> 00:15:14,310
held it actually when Pluto and Charon

320
00:15:18,290 --> 00:15:16,050
come close enough together Pluto and

321
00:15:19,670 --> 00:15:18,300
Charon share an atmosphere it's actually

322
00:15:21,170 --> 00:15:19,680
the scale height rises to the point

323
00:15:24,410 --> 00:15:21,180
where you get actually atmosphere

324
00:15:26,870 --> 00:15:24,420
transfer from Pluto to Sharon which is

325
00:15:30,260 --> 00:15:26,880
again pretty crazy I just that just

326
00:15:32,480 --> 00:15:30,270
blows my mind but I think that it's

327
00:15:41,480 --> 00:15:32,490
still considered an exosphere at that