2017 Astrobiology Graduate Conference

CHARLOTTESVILLE, VA

1
00:00:00,790 --> 00:00:07,210
[Music]

2
00:00:11,780 --> 00:00:09,620
for those of you who don't know me I'm

3
00:00:14,990 --> 00:00:11,790
Jay crawl I also go by Alec that's how

4
00:00:16,760 --> 00:00:15,000
you'll find me on social media I use

5
00:00:20,000 --> 00:00:16,770
masculine gender pronouns he has in him

6
00:00:21,650 --> 00:00:20,010
and I study I'm a graduate student at

7
00:00:24,320 --> 00:00:21,660
the University of Colorado where I study

8
00:00:26,859 --> 00:00:24,330
one how gender and sexuality affect the

9
00:00:29,990 --> 00:00:26,869
academic outcomes for Gen chem students

10
00:00:32,150 --> 00:00:30,000
more topically I also study sulfur

11
00:00:34,700 --> 00:00:32,160
reactions and atmospheres in planetary

12
00:00:36,020 --> 00:00:34,710
atmospheres I'm not going to talk to you

13
00:00:38,270 --> 00:00:36,030

about either of those things this

14
00:00:46,270 --> 00:00:38,280
morning I'm going to talk to you about

15
00:00:53,860 --> 00:00:52,069
rocks cool so more specifically I'm

16
00:00:55,850 --> 00:00:53,870
going to talk to you a little bit about

17
00:00:57,590 --> 00:00:55,860
some of the rocks that you're going to

18
00:00:59,380 --> 00:00:57,600
hear about in this morning's session and

19
00:01:01,819 --> 00:00:59,390
why we care about them as

20
00:01:05,000 --> 00:01:01,829
astrobiologists to the geologists in the

21
00:01:10,070 --> 00:01:05,010
room please forgive me and correct me

22
00:01:11,270 --> 00:01:10,080
during the session after so the first

23
00:01:14,090 --> 00:01:11,280
rock that we're going to talk about is

24
00:01:16,670 --> 00:01:14,100
Venus it's often referred to as Earth's

25
00:01:18,649 --> 00:01:16,680
twin more accurately it might be

26
00:01:22,550 --> 00:01:18,659
described as our evil twin on a bad hair

27
00:01:25,760 --> 00:01:22,560
day but it's very similar to earth in

28
00:01:27,530 --> 00:01:25,770
size and mass and Composition but a

29
00:01:29,780 --> 00:01:27,540
couple of things make it very notably

30
00:01:31,749 --> 00:01:29,790
different especially at sulfuric acid

31
00:01:35,899 --> 00:01:31,759
clouds so from about 50 to 70 kilometers

32
00:01:39,440 --> 00:01:35,909
there's a global sulfuric acid cloud

33
00:01:42,200 --> 00:01:39,450
layer it also has an incredibly slow day

34
00:01:45,230 --> 00:01:42,210
so it takes about 243 Earth days for

35
00:01:46,730 --> 00:01:45,240
Venus to turn once on its axis and it

36
00:01:49,520 --> 00:01:46,740
also rotates in the opposite direction

37
00:01:51,289 --> 00:01:49,530
of all the other planets this is likely

38
00:01:56,450 --> 00:01:51,299

because of some massive cataclysmic

39
00:01:58,880 --> 00:01:56,460
collision or earlier in its history it

40
00:02:03,800 --> 00:01:58,890
also is incredibly hot at its surface

41
00:02:06,200 --> 00:02:03,810
about 500 degrees Celsius and if we take

42
00:02:08,210 --> 00:02:06,210
a look at its atmosphere that's a little

43
00:02:10,760 --> 00:02:08,220
bit easier to explain the surface

44
00:02:12,470 --> 00:02:10,770
pressure is 93 bar it's almost 100 times

45
00:02:12,830 --> 00:02:12,480
more pressure at its surface than on

46
00:02:15,559 --> 00:02:12,840
earth

47
00:02:18,050 --> 00:02:15,569
and that atmosphere is almost entirely

48
00:02:19,550 --> 00:02:18,060
carbon dioxide and so it has this

49
00:02:22,880 --> 00:02:19,560
incredibly potent greenhouse gas

50
00:02:26,270 --> 00:02:22,890
atmosphere there's some nitrogen as well

51
00:02:30,229 --> 00:02:26,280
as some other trace gases most notably

52
00:02:32,150 --> 00:02:30,239
so2 but because of that global cloud

53
00:02:35,449 --> 00:02:32,160
cover it has this incredibly high albedo

54
00:02:37,759 --> 00:02:35,459
which means that almost 90% of the light

55
00:02:39,920 --> 00:02:37,769
that is in coming from the Sun actually

56
00:02:41,509 --> 00:02:39,930
gets reflected away from Venus but the

57
00:02:44,420 --> 00:02:41,519
atmosphere is so thick that even that

58
00:02:46,970 --> 00:02:44,430
10% that gets in and absorbed by the

59
00:02:50,420 --> 00:02:46,980
planet leads to incredible heating of

60
00:02:52,460 --> 00:02:50,430
the surface there's also very little

61
00:02:56,300 --> 00:02:52,470
hydrogen and Venus's atmosphere and

62
00:02:58,610 --> 00:02:56,310
there's an incredibly high d2h ratio and

63
00:03:00,259 --> 00:02:58,620

so what that tells us is that actually

64
00:03:03,229 --> 00:03:00,269
Venus has probably lost a lot of the

65
00:03:05,210 --> 00:03:03,239
water from it which is interesting

66
00:03:07,039 --> 00:03:05,220
because early on its history we think

67
00:03:10,210 --> 00:03:07,049
Venus may have been a lot more like

68
00:03:12,830 --> 00:03:10,220
Earth and had oceans on its surface

69
00:03:18,020 --> 00:03:12,840
today its surface looks incredibly

70
00:03:21,650 --> 00:03:18,030
different though there is because of its

71
00:03:23,330 --> 00:03:21,660
similar size and density we assume that

72
00:03:26,539 --> 00:03:23,340
it's pretty similar to earth and that it

73
00:03:28,280 --> 00:03:26,549
has a core a mantle and a crust however

74
00:03:30,259 --> 00:03:28,290
we don't have a lot of actual direct

75
00:03:33,500 --> 00:03:30,269
evidence about the internal structure of

76
00:03:34,910 --> 00:03:33,510
the planet we don't see any evidence of

77
00:03:36,920 --> 00:03:34,920
plate tectonics which is pretty

78
00:03:41,690 --> 00:03:36,930
interesting and there's no magnetic

79
00:03:44,420 --> 00:03:41,700
field however most of the impact craters

80
00:03:47,660 --> 00:03:44,430
are almost in pristine condition the

81
00:03:49,039 --> 00:03:47,670
surface is very young only about 300 to

82
00:03:51,080 --> 00:03:49,049
600 million years old

83
00:03:54,080 --> 00:03:51,090
and there's been a lot of evidence of

84
00:03:56,420 --> 00:03:54,090
past volcanic activity and so what we

85
00:03:59,660 --> 00:03:56,430
think happens on Venus is that the crust

86
00:04:02,390 --> 00:03:59,670
is doesn't we don't have any of these

87
00:04:04,099 --> 00:04:02,400
plate tectonics right now but the mantle

88
00:04:06,080 --> 00:04:04,109

slowly heats up and at some point

89
00:04:08,090 --> 00:04:06,090
there's enough to actually enough energy

90
00:04:10,280 --> 00:04:08,100
to actually disrupt the crust and then

91
00:04:14,740 --> 00:04:10,290
we see massive turnover of the surface

92
00:04:17,090 --> 00:04:14,750
and resurfacing of the entire planet

93
00:04:19,009 --> 00:04:17,100
with so if we go a little bit farther

94
00:04:21,670 --> 00:04:19,019
out in our solar system we've got Titan

95
00:04:24,469 --> 00:04:21,680
it's the largest moon orbiting Saturn

96
00:04:25,980 --> 00:04:24,479
but perhaps most interesting is that

97
00:04:30,120 --> 00:04:25,990
it's the only moon with a

98
00:04:34,189 --> 00:04:30,130
atmosphere and the surface is composed

99
00:04:37,320 --> 00:04:34,199
mostly of water ice and rocky material

100
00:04:39,300 --> 00:04:37,330
but this dense atmosphere is possibly an

101
00:04:40,350 --> 00:04:39,310
analogue to early Earth's atmosphere

102
00:04:44,040 --> 00:04:40,360
which is what makes it really

103
00:04:46,620 --> 00:04:44,050
interesting to us as astrobiologists and

104
00:04:48,990 --> 00:04:46,630
so its atmosphere actually has a very

105
00:04:50,460 --> 00:04:49,000
similar structure to Earth it has this

106
00:04:53,129 --> 00:04:50,470
troposphere where we see all of its

107
00:04:54,960 --> 00:04:53,139
weather and then an upper stratosphere

108
00:04:58,260 --> 00:04:54,970
where there's a stolen haze which is

109
00:05:00,629 --> 00:04:58,270
mostly carbon containing organics with

110
00:05:03,240 --> 00:05:00,639
some nitrogen in them and then a miso

111
00:05:05,939 --> 00:05:03,250
sphere and thermosphere its atmosphere

112
00:05:09,180 --> 00:05:05,949
is almost 90 almost entirely nitrogen

113
00:05:10,350 --> 00:05:09,190

it's about 98% nitrogen we do see some

114
00:05:13,080 --> 00:05:10,360
methane

115
00:05:15,060 --> 00:05:13,090
it's 1.2 percent overall but as you go

116
00:05:18,089 --> 00:05:15,070
closer to the surface actually increases

117
00:05:20,909 --> 00:05:18,099
to about 5% of the atmosphere and that's

118
00:05:22,620 --> 00:05:20,919
because it's incredibly cold and so that

119
00:05:24,540 --> 00:05:22,630
methane actually begins to freeze out

120
00:05:28,550 --> 00:05:24,550
and you get precipitation of it on the

121
00:05:31,680 --> 00:05:28,560
planet in this lower troposphere and

122
00:05:33,210 --> 00:05:31,690
there's a little bit of hydrogen and

123
00:05:35,010 --> 00:05:33,220
then there's a lot of trace organics

124
00:05:40,550 --> 00:05:35,020
formed because of the photo chemistry

125
00:05:42,930 --> 00:05:40,560
that goes on with methane before Cassini

126
00:05:46,350 --> 00:05:42,940
cassini-huygens we actually did not know

127
00:05:48,060 --> 00:05:46,360
a whole lot about Titan surface

128
00:05:50,040 --> 00:05:48,070
thanks to that mission we actually do

129
00:05:52,740 --> 00:05:50,050
now know that there are hydrocarbon

130
00:05:54,300 --> 00:05:52,750
lakes and rivers and that the surface is

131
00:05:56,070 --> 00:05:54,310
actually pretty geologically young

132
00:05:57,870 --> 00:05:56,080
somewhere between a hundred and a

133
00:06:01,379 --> 00:05:57,880
billion 100 million and a billion years

134
00:06:04,890 --> 00:06:01,389
old but we can actually see these canals

135
00:06:07,170 --> 00:06:04,900
and rivers on the surface as well as a

136
00:06:11,070 --> 00:06:07,180
number of lakes at the northern pole of

137
00:06:13,290 --> 00:06:11,080
the moon as well and then also

138
00:06:16,020 --> 00:06:13,300

particularly interesting it has a rocky

139
00:06:17,760 --> 00:06:16,030
silicate core about 3,400 kilometers in

140
00:06:20,430 --> 00:06:17,770
diameter so it's a little bit bigger

141
00:06:23,790 --> 00:06:20,440
than Earth's moon but smaller than the

142
00:06:26,790 --> 00:06:23,800
earth but there's a lot of evidence that

143
00:06:30,089 --> 00:06:26,800
there is a subsurface ocean possibly a

144
00:06:32,070 --> 00:06:30,099
global ocean and what we think would

145
00:06:34,980 --> 00:06:32,080
allow for this is actually an ammonia

146
00:06:36,899 --> 00:06:34,990
water mixture so once you have enough

147
00:06:40,019 --> 00:06:36,909
ammonia in that water you can get this

148
00:06:45,060 --> 00:06:40,029
eutectic mixture that doesn't freeze out

149
00:06:46,379 --> 00:06:45,070
until much colder and so that also gives

150
00:06:48,680 --> 00:06:46,389
us the potential for a lot of

151
00:06:53,279 --> 00:06:48,690
interesting chemistry and importance for

152
00:06:54,390 --> 00:06:53,289
astrobiology the next rock that we're

153
00:06:57,209 --> 00:06:54,400
probably going to hear about is

154
00:06:59,579 --> 00:06:57,219
meteoroids and the IAU definition is

155
00:07:01,909 --> 00:06:59,589
incredibly specific it's a solid object

156
00:07:04,620 --> 00:07:01,919
moving in the interplanetary space of

157
00:07:06,570 --> 00:07:04,630
considerable size considerably smaller

158
00:07:11,579 --> 00:07:06,580
than an asteroid and considerably larger

159
00:07:13,920 --> 00:07:11,589
than an atom and so this actually gives

160
00:07:16,730 --> 00:07:13,930
us a pretty wide berth but most of these

161
00:07:20,370 --> 00:07:16,740
things are about 4.5 billion years old

162
00:07:22,079 --> 00:07:20,380
and perhaps most interestingly about 15

163
00:07:24,420 --> 00:07:22,089

thousand metric tons of these are

164
00:07:28,140 --> 00:07:24,430
delivered to earth every year and so

165
00:07:30,510 --> 00:07:28,150
these are a source of incoming material

166
00:07:33,689 --> 00:07:30,520
that can seed the planet with a lot of

167
00:07:37,079 --> 00:07:33,699
interesting material over you know the

168
00:07:38,879 --> 00:07:37,089
course of billions of years additionally

169
00:07:42,329 --> 00:07:38,889
most of them come from the asteroid belt

170
00:07:44,579 --> 00:07:42,339
about 99.8% of meteorites that we've

171
00:07:46,409 --> 00:07:44,589
found have come from there and so they

172
00:07:50,300 --> 00:07:46,419
can tell us a lot about the early solar

173
00:07:52,649 --> 00:07:50,310
system composition and some is well our

174
00:07:54,089 --> 00:07:52,659
cometary debris and so that's normally

175
00:07:57,480 --> 00:07:54,099
what we would refer to is like a meteor

176
00:07:59,640 --> 00:07:57,490
shower and then a very small number of

177
00:08:01,469 --> 00:07:59,650
them are ejected material from

178
00:08:04,469 --> 00:08:01,479
collisions with much larger body such as

179
00:08:06,829 --> 00:08:04,479
Mars in the moon and so these are some

180
00:08:11,189 --> 00:08:06,839
of the first hints that we got at what

181
00:08:15,749 --> 00:08:11,199
composition what the composition of Mars

182
00:08:17,159 --> 00:08:15,759
and the moon were after that we'll hear

183
00:08:19,589 --> 00:08:17,169
about some stromatolite some

184
00:08:20,879 --> 00:08:19,599
stromatolites are a little bit different

185
00:08:23,040 --> 00:08:20,889
than all the other rocks we'll be

186
00:08:24,930 --> 00:08:23,050
talking about one there here on earth

187
00:08:26,969 --> 00:08:24,940
which is exciting

188
00:08:30,240 --> 00:08:26,979

but they're built by living microbial

189
00:08:31,740 --> 00:08:30,250
colonies of cyanobacteria and on the

190
00:08:35,430 --> 00:08:31,750
modern earth they're actually found in

191
00:08:37,860 --> 00:08:35,440
only a very few select places such as

192
00:08:39,209 --> 00:08:37,870
Shark Bay and in the Caribbean and this

193
00:08:40,980 --> 00:08:39,219
is because they have to form in very

194
00:08:45,270 --> 00:08:40,990
hyper saline conditions and I'll talk a

195
00:08:46,829 --> 00:08:45,280
little more about that here but in the

196
00:08:47,429 --> 00:08:46,839
Precambrian area they were fairly

197
00:08:49,860 --> 00:08:47,439
ubiquitous

198
00:08:51,300 --> 00:08:49,870
all over the planet and they may date

199
00:08:54,059 --> 00:08:51,310
back all the way back to the Ark

200
00:08:55,590 --> 00:08:54,069
so there's some of the earliest forms of

201
00:08:57,480 --> 00:08:55,600
life that we see on the planet that we

202
00:09:01,230 --> 00:08:57,490
actually have like really nice records

203
00:09:03,749 --> 00:09:01,240
of and so the way these things form

204
00:09:07,019 --> 00:09:03,759
cyanobacteria are these photosynthetic

205
00:09:09,090 --> 00:09:07,029
species so they need to be able to get

206
00:09:14,069 --> 00:09:09,100
sunlight to grow but you get these mats

207
00:09:16,290 --> 00:09:14,079
of cyanobacteria and then they form on

208
00:09:20,280 --> 00:09:16,300
the shallow waters the deepest been

209
00:09:21,840 --> 00:09:20,290
found about 14 meters or 45 feet but as

210
00:09:24,269 --> 00:09:21,850
they do that they build up this mucus

211
00:09:27,239 --> 00:09:24,279
layer that can trap sediment or they can

212
00:09:29,939 --> 00:09:27,249
precipitate calcite as well but as that

213
00:09:32,040 --> 00:09:29,949

happens then they grow up through that

214
00:09:33,900 --> 00:09:32,050
layer and they start a new mat and then

215
00:09:35,489 --> 00:09:33,910
they grow out and then they collect more

216
00:09:36,960 --> 00:09:35,499
sediment and then they get another layer

217
00:09:38,160 --> 00:09:36,970
and they grow up through it and then

218
00:09:41,100 --> 00:09:38,170
they start another layer and they do

219
00:09:43,619 --> 00:09:41,110
this over and over again and so they

220
00:09:45,269 --> 00:09:43,629
trap a lot of the interesting material

221
00:09:47,340 --> 00:09:45,279
so they tell us a lot about what the

222
00:09:50,160 --> 00:09:47,350
conditions were when they were growing

223
00:09:54,210 --> 00:09:50,170
what was available what was settling out

224
00:09:55,650 --> 00:09:54,220
in the oceans but it's important that

225
00:09:58,470 --> 00:09:55,660
they need to be free of any sort of

226
00:10:00,869 --> 00:09:58,480
grazing species so if anything eats them

227
00:10:02,999 --> 00:10:00,879
then they can't build these rocks that's

228
00:10:05,040 --> 00:10:03,009
very problematic in today's oceans

229
00:10:07,139 --> 00:10:05,050
however pre-cambrian there weren't any

230
00:10:09,389 --> 00:10:07,149
fish or anything eating them so we have

231
00:10:10,590 --> 00:10:09,399
a lot of them around and you get them in

232
00:10:12,960 --> 00:10:10,600
all sorts of really interesting

233
00:10:18,449 --> 00:10:12,970
structures from domes to columns to

234
00:10:20,340 --> 00:10:18,459
splitting columns and then the last Rock

235
00:10:22,410 --> 00:10:20,350
we'll call it a rock iron-sulfur

236
00:10:25,769 --> 00:10:22,420
clusters think of them as very tiny

237
00:10:27,720 --> 00:10:25,779
rocks that are important in biology but

238
00:10:30,569 --> 00:10:27,730

they're made out of unsurprisingly iron

239
00:10:32,220 --> 00:10:30,579
and sulfur and they come in a really

240
00:10:34,019 --> 00:10:32,230
wide variety of different structures

241
00:10:36,150 --> 00:10:34,029
depending on how much iron and sulfur

242
00:10:39,210 --> 00:10:36,160
you have in them anywhere from very

243
00:10:44,030 --> 00:10:39,220
simple one in two atoms of iron and

244
00:10:46,470 --> 00:10:44,040
sulfur up to a much larger structures

245
00:10:48,449 --> 00:10:46,480
but interestingly they're found in a

246
00:10:49,889 --> 00:10:48,459
number of proteins in biology and

247
00:10:51,929 --> 00:10:49,899
there's at least three biosynthetic

248
00:10:54,210 --> 00:10:51,939
systems that have been identified for

249
00:10:58,199 --> 00:10:54,220
making these things in our biological

250
00:11:00,030 --> 00:10:58,209
systems and what's really interesting is

251
00:11:03,030 --> 00:11:00,040
they play a really important role in

252
00:11:04,710 --> 00:11:03,040
redox oxidation reactions in

253
00:11:06,869 --> 00:11:04,720
mitochondria

254
00:11:08,819 --> 00:11:06,879
both complex 1 & 2 an oxidative

255
00:11:11,939 --> 00:11:08,829
phosphorylation have multiple iron

256
00:11:14,160 --> 00:11:11,949
sulfur clusters in them they can also

257
00:11:17,220 --> 00:11:14,170
act as catalytic centers for a lot of

258
00:11:19,400 --> 00:11:17,230
biological activity and because of this

259
00:11:22,499 --> 00:11:19,410
they've been suggested as playing an

260
00:11:27,059 --> 00:11:22,509
important role in the origin of life on

261
00:11:30,720 --> 00:11:27,069
Earth and so with that I will thank you

262
00:11:32,790 --> 00:11:30,730
guys for your time and hand things over

263
00:11:34,230 --> 00:11:32,800

to the experts that are going to be

264
00:11:38,690 --> 00:11:34,240
giving talks dare I call them the rock