2017 Astrobiology Graduate Conference

Charlottesville, VA

1
00:00:00,790 --> 00:00:08,799
[Music]

2
00:00:15,709 --> 00:00:12,200
hi guys I'm not as well dressed or as

3
00:00:17,420 --> 00:00:15,719
poetic as the previous guy but uh we'll

4
00:00:19,490 --> 00:00:17,430
see what I can do all right so I'm

5
00:00:21,679 --> 00:00:19,500
Jonathan you can call me Johnny

6
00:00:23,269 --> 00:00:21,689
I'm from Imperial College and today I'm

7
00:00:26,210 --> 00:00:23,279
going to talk about to talk to you about

8
00:00:27,500 --> 00:00:26,220
lipids on Mars so there are two very

9
00:00:28,849 --> 00:00:27,510
important questions that I want to try

10
00:00:31,130 --> 00:00:28,859
and answer during the course of this

11
00:00:33,229 --> 00:00:31,140
talk firstly can we understand the

12
00:00:35,690 --> 00:00:33,239
processes of preservation of bio markers

13
00:00:37,880 --> 00:00:35,700

in Martian environments and two how can

14
00:00:40,160 --> 00:00:37,890
we use that to tell us more about and

15
00:00:42,200 --> 00:00:40,170
inform us about future life detection

16
00:00:43,779 --> 00:00:42,210
missions on Mars and to do that I'm

17
00:00:45,920 --> 00:00:43,789
going to talk about biomarkers

18
00:00:47,540 --> 00:00:45,930
appropriate terrestrial analogs and how

19
00:00:49,700 --> 00:00:47,550
they work together to give us an idea of

20
00:00:52,580 --> 00:00:49,710
the preservation potential of these

21
00:00:54,350 --> 00:00:52,590
environments so first thing we need to

22
00:00:56,029 --> 00:00:54,360
ask ourselves is what are we looking for

23
00:00:57,619 --> 00:00:56,039
because there's no point spending a

24
00:00:59,779 --> 00:00:57,629
million dollars billions of dollars on a

25
00:01:01,340 --> 00:00:59,789
rover to send to Mars and we don't know

26
00:01:03,380 --> 00:01:01,350
what we want to find so the answer there

27
00:01:06,320 --> 00:01:03,390
is of course biomarkers which Bradley

28
00:01:08,750 --> 00:01:06,330
has kindly told us and the definition of

29
00:01:10,969 --> 00:01:08,760
which is here but the question is what

30
00:01:12,920 --> 00:01:10,979
makes a use of biomarker Y how do we

31
00:01:15,440 --> 00:01:12,930
learn to choose what biomarker we want

32
00:01:17,510 --> 00:01:15,450
so for example let's say that you want

33
00:01:19,609 --> 00:01:17,520
to find out more about dinosaurs okay

34
00:01:22,010 --> 00:01:19,619
what biomarker to use for dinosaurs and

35
00:01:23,450 --> 00:01:22,020
the answer that is bones and there are

36
00:01:25,399 --> 00:01:23,460
two reasons there are two reasons why

37
00:01:27,140 --> 00:01:25,409
you use bones as a biomarker of

38
00:01:28,539 --> 00:01:27,150

dinosaurs the first one is that they're

39
00:01:31,100 --> 00:01:28,549
highly resistant to degradation

40
00:01:32,359 --> 00:01:31,110
dinosaurs died millions of years ago and

41
00:01:34,700 --> 00:01:32,369
you can still find bones in pristine

42
00:01:36,920 --> 00:01:34,710
conditions today the second thing is

43
00:01:38,569 --> 00:01:36,930
that bones are highly diagnostic of

44
00:01:39,770 --> 00:01:38,579
different types of dinosaurs for example

45
00:01:41,600 --> 00:01:39,780
if you see the plates of a Stegosaurus

46
00:01:43,580 --> 00:01:41,610
then you know that they're from a

47
00:01:47,030 --> 00:01:43,590
Stegosaurus and not from a t-rex for

48
00:01:48,920 --> 00:01:47,040
example so similarly when we look at

49
00:01:51,020 --> 00:01:48,930
microbial mats on Mars which is why we

50
00:01:55,760 --> 00:01:51,030
think I would have been the most evolved

51
00:01:56,990 --> 00:01:55,770
life on Mars we look at lipids so you

52
00:01:58,429 --> 00:01:57,000
guys already know what lipids are

53
00:02:01,069 --> 00:01:58,439
because Bradley told you what they were

54
00:02:02,660 --> 00:02:01,079
but essentially they are fatty acids we

55
00:02:05,149 --> 00:02:02,670
have a variety of functions in the cell

56
00:02:07,760 --> 00:02:05,159
such as triglycerides as energy stores

57
00:02:10,190 --> 00:02:07,770
glycol lipids as signalers and perhaps

58
00:02:12,020 --> 00:02:10,200
most importantly phospholipids as the

59
00:02:12,740 --> 00:02:12,030
components of some membranes which means

60
00:02:14,600 --> 00:02:12,750
that as

61
00:02:17,900 --> 00:02:14,610
long as your organism had a cell

62
00:02:20,390 --> 00:02:17,910
membrane it will have lipids so similar

63
00:02:21,800 --> 00:02:20,400

to bones lipids the hydrocarbon

64
00:02:24,230 --> 00:02:21,810
derivatives of lipids are highly

65
00:02:26,540 --> 00:02:24,240
resistant to degradation and lipids can

66
00:02:28,670 --> 00:02:26,550
be diagnostic indicators of different

67
00:02:31,550 --> 00:02:28,680
biosynthetic pathways or of different

68
00:02:33,920 --> 00:02:31,560
domains of life so now that we figured

69
00:02:36,199 --> 00:02:33,930
out what we want to look for we need to

70
00:02:37,190 --> 00:02:36,209
figure out where to look for them and in

71
00:02:39,650 --> 00:02:37,200
order to do that we need to identify

72
00:02:41,930 --> 00:02:39,660
what the most common rock types that

73
00:02:44,060 --> 00:02:41,940
were deposited in various p major

74
00:02:45,560 --> 00:02:44,070
periods of Martian history and we look

75
00:02:47,690 --> 00:02:45,570
at that through the mineralogical errors

76
00:02:49,760 --> 00:02:47,700
the fellow seein that the ekayon and the

77
00:02:51,080 --> 00:02:49,770
city rican and we can further constrain

78
00:02:52,790 --> 00:02:51,090
where we look for these rocks by

79
00:02:56,449 --> 00:02:52,800
figuring out where there is evidence for

80
00:02:58,370 --> 00:02:56,459
liquid water now the question is how do

81
00:03:00,440 --> 00:02:58,380
we understand the processes that are

82
00:03:02,660 --> 00:03:00,450
occurring in the environments millions

83
00:03:04,520 --> 00:03:02,670
and millions of miles away and we do

84
00:03:06,710 --> 00:03:04,530
this by using terrestrial analogs which

85
00:03:09,080 --> 00:03:06,720
are locations on earth that are assumed

86
00:03:11,150 --> 00:03:09,090
to mimic some if not all of the

87
00:03:14,240 --> 00:03:11,160
environmental conditions of Mars such as

88
00:03:16,430 --> 00:03:14,250

geological biological chemical and the

89
00:03:18,170 --> 00:03:16,440
reason why we do this is well we can't

90
00:03:20,060 --> 00:03:18,180
get Martian rocks just yet there's no

91
00:03:23,420 --> 00:03:20,070
sample return missions and with Trump in

92
00:03:25,400 --> 00:03:23,430
charge there may never be so instead we

93
00:03:27,140 --> 00:03:25,410
look closer to earth we try understand

94
00:03:29,840 --> 00:03:27,150
processes occurring on earth and then

95
00:03:32,000 --> 00:03:29,850
extrapolate that to Mars and so for

96
00:03:33,979 --> 00:03:32,010
example the fill ocean which comprises

97
00:03:35,360 --> 00:03:33,989
mostly of iron-rich clays they are

98
00:03:37,670 --> 00:03:35,370
derived from the weathering of mafic

99
00:03:40,130 --> 00:03:37,680
bath salts we use glazed oils or

100
00:03:42,289 --> 00:03:40,140
volcanic clastic sediments as simulants

101
00:03:44,479 --> 00:03:42,299
for this environment similarly when we

102
00:03:46,130 --> 00:03:44,489
look at the vehicle which is mostly jera

103
00:03:49,160 --> 00:03:46,140
sites which is an iron surface salt

104
00:03:51,259 --> 00:03:49,170
because the Deccan had a lot of sulfur

105
00:03:53,270 --> 00:03:51,269
outgassing we look at acid mine drainage

106
00:03:55,430 --> 00:03:53,280
or sulfur stream so for example this is

107
00:03:58,729 --> 00:03:55,440
one of the classical terrestrial

108
00:04:00,380 --> 00:03:58,739
analogues Rio Tinto in Spain and finally

109
00:04:02,750 --> 00:04:00,390
in the city region where there is mostly

110
00:04:05,810 --> 00:04:02,760
very high dry and other anhydrous ferric

111
00:04:07,039 --> 00:04:05,820
oxide we look at iron bogs and fens now

112
00:04:08,539 --> 00:04:07,049
these are still a lot of variety of

113
00:04:11,090 --> 00:04:08,549

environments so today I'm going to focus

114
00:04:13,250 --> 00:04:11,100
on my work in the thean environment and

115
00:04:16,009 --> 00:04:13,260
this particular terrestrial analogue so

116
00:04:17,599 --> 00:04:16,019
let's take a closer look at that so this

117
00:04:20,060 --> 00:04:17,609
is a this is a picture of my study area

118
00:04:23,990 --> 00:04:20,070
there is a guy here for size for scale

119
00:04:26,089 --> 00:04:24,000
geologists very careful about scales so

120
00:04:26,570 --> 00:04:26,099
what what let's take a look low so like

121
00:04:27,890 --> 00:04:26,580
I want to

122
00:04:29,929 --> 00:04:27,900
Oh screaming so this is a self esteem

123
00:04:32,119 --> 00:04:29,939
self esteems are caused by the

124
00:04:34,550 --> 00:04:32,129
dissolution of sulfides usually it is

125
00:04:37,189 --> 00:04:34,560
pyrite into water and what happens is

126
00:04:39,679 --> 00:04:37,199
that that this eventually deposits jera

127
00:04:41,570 --> 00:04:39,689
sites which an iron sulfate salt and is

128
00:04:43,700 --> 00:04:41,580
very similar to terror to environments

129
00:04:44,450 --> 00:04:43,710
formed on Mars such as in Meridiani

130
00:04:47,059 --> 00:04:44,460
Planum

131
00:04:48,909 --> 00:04:47,069
now as you can see very clearly these

132
00:04:51,379 --> 00:04:48,919
environments are capable of supporting

133
00:04:52,969 --> 00:04:51,389
extremely for the organisms ecosystems

134
00:04:54,860 --> 00:04:52,979
of these extremophiles organisms and

135
00:04:56,899 --> 00:04:54,870
these are very useful to us because if

136
00:04:59,119 --> 00:04:56,909
these environments can support extrema

137
00:05:00,740 --> 00:04:59,129
philic organism earth then these same

138
00:05:03,409 --> 00:05:00,750

invariants may have been able to sport

139
00:05:05,270 --> 00:05:03,419
similar organisms on Mars and if we can

140
00:05:07,100 --> 00:05:05,280
find out how what these organisms look

141
00:05:09,260 --> 00:05:07,110
like and how they are preserved in Earth

142
00:05:10,879 --> 00:05:09,270
rocks then we can figure out what they

143
00:05:14,360 --> 00:05:10,889
would look like if they had been on Mars

144
00:05:16,369 --> 00:05:14,370
and are preserved in Mars rocks so once

145
00:05:18,110 --> 00:05:16,379
again this is where my study area is of

146
00:05:21,589 --> 00:05:18,120
course the best analogues for Mars are

147
00:05:23,089 --> 00:05:21,599
found the south coast of England we like

148
00:05:24,559 --> 00:05:23,099
most other selfish streams this surface

149
00:05:25,790 --> 00:05:24,569
stream is derived from pyrite in the

150
00:05:28,969 --> 00:05:25,800
wheeldin beds in the surroundings

151
00:05:30,980 --> 00:05:28,979
geology and like Mariana Planum the

152
00:05:32,570 --> 00:05:30,990
primary meteorology is jarosite but

153
00:05:34,399 --> 00:05:32,580
there's also good light which is an iron

154
00:05:34,999 --> 00:05:34,409
oxide derived from the transmission of

155
00:05:37,580 --> 00:05:35,009
this jarosite

156
00:05:39,649 --> 00:05:37,590
under humid conditions also present of

157
00:05:42,050 --> 00:05:39,659
course is the ever-present Clay's now

158
00:05:44,990 --> 00:05:42,060
the organic inputs into this environment

159
00:05:46,490 --> 00:05:45,000
include acidophilic algae microbial mats

160
00:05:48,409 --> 00:05:46,500
which are primarily purple sulfur

161
00:05:50,480 --> 00:05:48,419
bacteria as well as like netic wood and

162
00:05:52,760 --> 00:05:50,490
what we try to investigate is how the

163
00:05:54,920 --> 00:05:52,770

lipids from these organic inputs are

164
00:05:57,589 --> 00:05:54,930
preserved in rocks in these sulfur rich

165
00:06:00,200 --> 00:05:57,599
environments so this is how we do it

166
00:06:01,730 --> 00:06:00,210
firstly we collect a bunch of samples we

167
00:06:03,019 --> 00:06:01,740
took nine different course in order to

168
00:06:06,070 --> 00:06:03,029
sample the lateral and vertical

169
00:06:08,719 --> 00:06:06,080
variations in the stream we then

170
00:06:10,999 --> 00:06:08,729
separate them by mineralogy send them

171
00:06:12,409 --> 00:06:11,009
for XRD analysis powder them so that we

172
00:06:14,149 --> 00:06:12,419
can prepare them for blind eye

173
00:06:16,430 --> 00:06:14,159
extraction which is a type of liquid

174
00:06:19,010 --> 00:06:16,440
liquid extraction technique that will

175
00:06:20,719 --> 00:06:19,020
remove the lipids from these samples we

176
00:06:23,329 --> 00:06:20,729
then derivatives them and put them on a

177
00:06:26,420 --> 00:06:23,339
gas chromatography mass spectrometer aka

178
00:06:28,459 --> 00:06:26,430
the GCMs now before I show you the gist

179
00:06:30,140 --> 00:06:28,469
this GCMs data let's take a look at what

180
00:06:31,850 --> 00:06:30,150
a core profile would look like in this

181
00:06:34,010 --> 00:06:31,860
soft stream so at the very top you have

182
00:06:35,839 --> 00:06:34,020
your microbial mat beneath that you have

183
00:06:37,459 --> 00:06:35,849
a gut layer that slow transitions into

184
00:06:40,200 --> 00:06:37,469
jarosite and the very bottom you have

185
00:06:43,170 --> 00:06:40,210
clays so this is the GCMs data where

186
00:06:45,600 --> 00:06:43,180
3m represents a microbial mat sample 3r

187
00:06:48,990 --> 00:06:45,610
represents a gunite sample and 3c

188
00:06:51,330 --> 00:06:49,000

represents a clay sample now not many of

189
00:06:53,490 --> 00:06:51,340
you may know how to interpret GCMs data

190
00:06:55,469 --> 00:06:53,500
so what is what you're showing here is

191
00:06:57,180 --> 00:06:55,479
the GC data each of these Peaks

192
00:06:58,830 --> 00:06:57,190
represents a different organic molecule

193
00:07:00,809 --> 00:06:58,840
in this case a different lipid species

194
00:07:02,700 --> 00:07:00,819
and you can identify that lipid species

195
00:07:05,999 --> 00:07:02,710
by looking at the mass spectrometer part

196
00:07:07,740 --> 00:07:06,009
the data the MS part of data the height

197
00:07:09,450 --> 00:07:07,750
of those Peaks represents the relative

198
00:07:11,309 --> 00:07:09,460
abundance of that particular lipid

199
00:07:14,100 --> 00:07:11,319
species to a different to all the other

200
00:07:16,020 --> 00:07:14,110
Peaks and we usually use an internal

201
00:07:19,140 --> 00:07:16,030
standard in this case the is to help

202
00:07:22,070 --> 00:07:19,150
give us a Quantic quantification of how

203
00:07:24,120 --> 00:07:22,080
much lipid there is in this sample so

204
00:07:26,460 --> 00:07:24,130
what do we want to find out from this

205
00:07:27,450 --> 00:07:26,470
GCMs data well obviously you want to

206
00:07:29,279 --> 00:07:27,460
figure out what lipids are being

207
00:07:31,260 --> 00:07:29,289
preserved secondly we want to figure out

208
00:07:33,330 --> 00:07:31,270
there any patterns in lipid preservation

209
00:07:36,120 --> 00:07:33,340
that would be able to distinguish them

210
00:07:37,890 --> 00:07:36,130
from abiotic sources or you then want to

211
00:07:39,839 --> 00:07:37,900
figure out if what these biomarkers can

212
00:07:42,360 --> 00:07:39,849
tell us about the organisms living in

213
00:07:43,499 --> 00:07:42,370

these environments and lastly we want to

214
00:07:45,360 --> 00:07:43,509
figure out if there's a preservation

215
00:07:46,589 --> 00:07:45,370
bias are some lipids better preserved

216
00:07:50,580 --> 00:07:46,599
than others and while the factors that

217
00:07:52,830 --> 00:07:50,590
affect them so before I go into the raw

218
00:07:54,029 --> 00:07:52,840
data etc let's take you let's remember

219
00:07:55,800 --> 00:07:54,039
what the different types of lipids are

220
00:07:57,360 --> 00:07:55,810
so these are saturated lipids they don't

221
00:07:59,100 --> 00:07:57,370
have any functional groups other than

222
00:08:00,839 --> 00:07:59,110
the carboxyl group at the end and the

223
00:08:01,890 --> 00:08:00,849
other fatty acids they are named

224
00:08:03,390 --> 00:08:01,900
depending on what functional group we

225
00:08:06,510 --> 00:08:03,400
have for example a double bond an extra

226
00:08:08,430 --> 00:08:06,520
methyl group or a hydroxyl group so this

227
00:08:11,850 --> 00:08:08,440
is the GCMs data except with colors this

228
00:08:13,320 --> 00:08:11,860
time you have abundance on the y-axis

229
00:08:16,439 --> 00:08:13,330
the different lipid species on the

230
00:08:17,999 --> 00:08:16,449
x-axis and each of those colored boxes

231
00:08:20,219 --> 00:08:18,009
represents a different group or

232
00:08:22,260 --> 00:08:20,229
different family of lipids now the one

233
00:08:24,180 --> 00:08:22,270
thing that should stick out to you is

234
00:08:26,600 --> 00:08:24,190
that there seem to be a lot larger

235
00:08:28,950 --> 00:08:26,610
abundance and diversity of lipids in the

236
00:08:30,959 --> 00:08:28,960
Gotha layer as compared to the clay

237
00:08:33,300 --> 00:08:30,969
layer now for geologists that seems

238
00:08:35,370 --> 00:08:33,310

really weird because clays are generally

239
00:08:37,829 --> 00:08:35,380
bought associated with the preservation

240
00:08:40,440 --> 00:08:37,839
of organic molecules then for example an

241
00:08:42,779 --> 00:08:40,450
iron oxide as you can see the clays only

242
00:08:45,480 --> 00:08:42,789
possess c16 and c18 saturated fatty

243
00:08:47,010 --> 00:08:45,490
acids so I'll talk about that later but

244
00:08:49,350 --> 00:08:47,020
another thing I would like to point out

245
00:08:51,600 --> 00:08:49,360
to you is what we call an even overall

246
00:08:54,060 --> 00:08:51,610
predominance in the carbon chain lengths

247
00:08:57,810 --> 00:08:54,070
of the saturated fatty acids so

248
00:09:00,330 --> 00:08:57,820
c14 c16 and c18 carbon are much higher

249
00:09:02,640 --> 00:09:00,340
in abundance than c 15 and C 17 carbons

250
00:09:04,620 --> 00:09:02,650
and this makes sense because this is a

251
00:09:06,690 --> 00:09:04,630
configuration that's very preferred by

252
00:09:08,280 --> 00:09:06,700
terrestrial organisms but what this

253
00:09:09,840 --> 00:09:08,290
means that this is a Biogen pattern

254
00:09:12,120 --> 00:09:09,850
right you can't form this kind of

255
00:09:13,740 --> 00:09:12,130
pattern abiotic lis so this is a pattern

256
00:09:18,210 --> 00:09:13,750
that would be good for distinguishing

257
00:09:20,130 --> 00:09:18,220
between biotic and abiotic signals so

258
00:09:22,470 --> 00:09:20,140
next let's take a look at what these

259
00:09:24,690 --> 00:09:22,480
biomark can tell us about the organisms

260
00:09:25,920 --> 00:09:24,700
that lived in these environments so we

261
00:09:27,120 --> 00:09:25,930
can split them into two there are

262
00:09:29,190 --> 00:09:27,130
general and specific biological

263
00:09:31,290 --> 00:09:29,200

indicators a general biology indicator

264
00:09:33,990 --> 00:09:31,300
is something that is indicative of life

265
00:09:35,370 --> 00:09:34,000
in general and usually these are the

266
00:09:37,110 --> 00:09:35,380
most well preserves and they should be

267
00:09:40,620 --> 00:09:37,120
ubiquitous in all samples and in this

268
00:09:42,660 --> 00:09:40,630
case it would be c16 and c18 saturated

269
00:09:44,070 --> 00:09:42,670
fatty acids because as you can saw as

270
00:09:45,840 --> 00:09:44,080
you saw they were found in all samples

271
00:09:47,070 --> 00:09:45,850
including clays and this makes sense

272
00:09:48,780 --> 00:09:47,080
because they're the most common

273
00:09:51,450 --> 00:09:48,790
saturated fatty acids in all of

274
00:09:53,070 --> 00:09:51,460
organisms the only thing is that these

275
00:09:55,500 --> 00:09:53,080
don't provide a lot of texts on my data

276
00:09:57,600 --> 00:09:55,510
so we look to specific biological

277
00:09:59,580 --> 00:09:57,610
markers to tell us that and we can use

278
00:10:01,650 --> 00:09:59,590
these to figure out whether or not

279
00:10:05,820 --> 00:10:01,660
something was an anaerobe an Arab a

280
00:10:07,800 --> 00:10:05,830
bacteria or archaea now some of these

281
00:10:09,510 --> 00:10:07,810
are not super useful for example we

282
00:10:12,270 --> 00:10:09,520
don't think that life on Mars would have

283
00:10:14,430 --> 00:10:12,280
developed aerobic metabolism or plants

284
00:10:15,870 --> 00:10:14,440
so we can cross those out but the rest

285
00:10:18,290 --> 00:10:15,880
of them are still very relevant in case

286
00:10:21,000 --> 00:10:18,300
we find any organic signals on Mars

287
00:10:22,470 --> 00:10:21,010
unfortunately one thing you need to

288
00:10:25,190 --> 00:10:22,480

notice is that most of these are

289
00:10:27,150 --> 00:10:25,200
functional functionalized lipids and

290
00:10:28,710 --> 00:10:27,160
what usually happens is that

291
00:10:30,270 --> 00:10:28,720
functionalize lipids aren't very well

292
00:10:32,940 --> 00:10:30,280
preserved so this is the relative degree

293
00:10:35,010 --> 00:10:32,950
of preservation on the y-axis over the

294
00:10:36,900 --> 00:10:35,020
lipid diversity on the x-axis and you

295
00:10:38,730 --> 00:10:36,910
can see that so these are the

296
00:10:40,620 --> 00:10:38,740
functionalize lipids and you can see

297
00:10:42,330 --> 00:10:40,630
that the relative degree of preservation

298
00:10:44,640 --> 00:10:42,340
is much lower for these lipids as

299
00:10:46,800 --> 00:10:44,650
compared to the saturated fatty acids so

300
00:10:49,200 --> 00:10:46,810
although functionalize lipids are very

301
00:10:51,360 --> 00:10:49,210
good at telling us taxonomy information

302
00:10:53,400 --> 00:10:51,370
about the organisms that live in these

303
00:10:55,680 --> 00:10:53,410
environments they may not be very well

304
00:10:58,530 --> 00:10:55,690
preserved or Martian on Martian

305
00:10:59,940 --> 00:10:58,540
environments right so this is the

306
00:11:01,740 --> 00:10:59,950
preservation bias that we need to take

307
00:11:04,050 --> 00:11:01,750
an account off when we look at Mars

308
00:11:06,960 --> 00:11:04,060
so what other what other things could

309
00:11:07,769 --> 00:11:06,970
affect this preservation bias well there

310
00:11:09,869 --> 00:11:07,779
appears to be a min

311
00:11:12,509 --> 00:11:09,879
gobias as we saw because goethite

312
00:11:14,730 --> 00:11:12,519
possessed more fatty acids then did the

313
00:11:16,530 --> 00:11:14,740

Clay's and that's really unusual so

314
00:11:18,179 --> 00:11:16,540
there could be a number of reasons for

315
00:11:19,860 --> 00:11:18,189
this right the gunfight contains more

316
00:11:22,949 --> 00:11:19,870
abundance and a higher diversity of

317
00:11:24,360 --> 00:11:22,959
lipids but the implication of this is

318
00:11:26,460 --> 00:11:24,370
that organic material could be

319
00:11:29,429 --> 00:11:26,470
sequestered in what we call a rusty sink

320
00:11:30,989 --> 00:11:29,439
these are the organic molecules could be

321
00:11:33,329 --> 00:11:30,999
attached to these ions and they could be

322
00:11:35,759 --> 00:11:33,339
buried and this is mimics a terrestrial

323
00:11:37,769 --> 00:11:35,769
phenomenon where up to 21% of organic

324
00:11:40,259 --> 00:11:37,779
carbon in terrestrial segments is bound

325
00:11:41,730 --> 00:11:40,269
to iron phases and so the implication of

326
00:11:44,009 --> 00:11:41,740
this and this is the one thing that you

327
00:11:45,780 --> 00:11:44,019
take away from this talk is that goodbye

328
00:11:49,170 --> 00:11:45,790
and other iron oxides could you have

329
00:11:50,519 --> 00:11:49,180
astrobiological portance on Mars so one

330
00:11:53,040 --> 00:11:50,529
more thing before I wrap at the top as

331
00:11:54,960 --> 00:11:53,050
you can obviously see these lipids were

332
00:11:56,970 --> 00:11:54,970
found in an extant community they were

333
00:11:58,439 --> 00:11:56,980
being produced in real time we need to

334
00:12:00,749 --> 00:11:58,449
find out what these lipids look like

335
00:12:03,629 --> 00:12:00,759
three to four billion years later right

336
00:12:05,579 --> 00:12:03,639
because Mars Mars life likely existed

337
00:12:06,989 --> 00:12:05,589
only 3 4 billion years ago so the

338
00:12:08,850 --> 00:12:06,999

primary process that me to look out for

339
00:12:11,100 --> 00:12:08,860
is what we call deep carboxylation and

340
00:12:12,509 --> 00:12:11,110
this is a very simplified explanation of

341
00:12:14,850 --> 00:12:12,519
what it is but essentially what happens

342
00:12:17,970 --> 00:12:14,860
is that your saturated fatty acids

343
00:12:20,100 --> 00:12:17,980
become alkanes by losing a co2 group and

344
00:12:21,360 --> 00:12:20,110
if you remember the even overawed

345
00:12:23,460 --> 00:12:21,370
predominance pattern that I talked about

346
00:12:25,290 --> 00:12:23,470
in the fatty acids well because you're

347
00:12:27,329 --> 00:12:25,300
losing a single carbon atom what happens

348
00:12:29,689 --> 00:12:27,339
is that this predominance becomes an

349
00:12:32,670 --> 00:12:29,699
over even predominance in alkanes and

350
00:12:35,610 --> 00:12:32,680
remember the general biological markers

351
00:12:41,220 --> 00:12:35,620
well they become from c16 and c18 fatty

352
00:12:43,199 --> 00:12:41,230
acids C 15 and C 17 alkanes so let's go

353
00:12:44,639 --> 00:12:43,209
over the conclusions let's return to the

354
00:12:47,639 --> 00:12:44,649
two questions that we asked themself at

355
00:12:49,259 --> 00:12:47,649
the very beginning of this lecture what

356
00:12:51,329 --> 00:12:49,269
are the processes of preservation of

357
00:12:53,999 --> 00:12:51,339
Mars and can we understand them answers

358
00:12:56,040 --> 00:12:54,009
yeah we can because we can use lipids as

359
00:12:58,530 --> 00:12:56,050
biomarkers we can select appropriate

360
00:13:00,869 --> 00:12:58,540
terrestrial analogs in this case sulfur

361
00:13:02,970 --> 00:13:00,879
streams for Tek and Mars we know that

362
00:13:04,559 --> 00:13:02,980
certain species of lipids can be used

363
00:13:06,030 --> 00:13:04,569

for as diagnostic indicators for

364
00:13:08,210 --> 00:13:06,040
different metabolisms or different

365
00:13:10,350 --> 00:13:08,220
domains of life but that these are

366
00:13:12,179 --> 00:13:10,360
affected by the preservation of these

367
00:13:13,889 --> 00:13:12,189
species depending on what species they

368
00:13:15,990 --> 00:13:13,899
are and what mineralogy is present in

369
00:13:17,790 --> 00:13:16,000
the analogue environment so how do we

370
00:13:20,940 --> 00:13:17,800
use this to figure out more about future

371
00:13:22,290 --> 00:13:20,950
missions to Mars well we know that we

372
00:13:23,700 --> 00:13:22,300
figured out that good fights and other

373
00:13:25,500 --> 00:13:23,710
iron oxides are possibly of

374
00:13:27,360 --> 00:13:25,510
astrobiological importance and we've

375
00:13:30,630 --> 00:13:27,370
identified several potential biogenic

376
00:13:33,360 --> 00:13:30,640
sanctions such as c16 and c18 saturated

377
00:13:36,030 --> 00:13:33,370
fatty acids as well as you pee or eel or

378
00:13:39,510 --> 00:13:36,040
sorry yo p or OAP patterns in fatty

379
00:13:59,010 --> 00:13:39,520
acids and alkanes respectively and thank

380
00:14:02,190 --> 00:13:59,020
you the n hi um for a given organism or

381
00:14:05,370 --> 00:14:02,200
organism group how many up to how many

382
00:14:06,930 --> 00:14:05,380
different lipids signatures can result

383
00:14:09,050 --> 00:14:06,940
is a strictly one-to-one or could it be

384
00:14:13,560 --> 00:14:09,060
many - well it could be many - one um

385
00:14:15,300 --> 00:14:13,570
mostly because basically many organisms

386
00:14:17,160 --> 00:14:15,310
organisms basically produce a large

387
00:14:18,450 --> 00:14:17,170
amount of lipids and this the lipids

388
00:14:20,130 --> 00:14:18,460

I've shown you are only a small fraction

389
00:14:21,690 --> 00:14:20,140
of that of that number there are many

390
00:14:22,770 --> 00:14:21,700
many other different types of little bio

391
00:14:24,360 --> 00:14:22,780
signatures that could be present

392
00:14:26,670 --> 00:14:24,370
depending on the type of organism and

393
00:14:28,710 --> 00:14:26,680
it's usually quite difficult to to

394
00:14:30,390 --> 00:14:28,720
pinpoint a specific lipid to a specific

395
00:14:32,100 --> 00:14:30,400
organism which is why sometimes you just

396
00:14:33,900 --> 00:14:32,110
have lipids that correspond to entire

397
00:14:36,270 --> 00:14:33,910
domains of life like for example certain

398
00:14:38,100 --> 00:14:36,280
but aspin lipid could say this is formed

399
00:14:43,620 --> 00:14:38,110
by bacteria but we have no idea what

400
00:14:45,120 --> 00:14:43,630
bacteria it is um in your preservation

401
00:14:48,450 --> 00:14:45,130
um

402
00:14:50,820 --> 00:14:48,460
slide your palmitic acid seem to be a

403
00:14:53,070 --> 00:14:50,830
lot less preserved than the stearic acid

404
00:14:55,260 --> 00:14:53,080
yeah it's just interesting that is it

405
00:14:56,820 --> 00:14:55,270
they're not very that they're very

406
00:14:57,990 --> 00:14:56,830
structurally similar and all yeah even

407
00:15:00,150 --> 00:14:58,000
that those are the two that show up the

408
00:15:01,530 --> 00:15:00,160
most that is that's quite an unusual and

409
00:15:04,170 --> 00:15:01,540
unusual pattern that we had I observed

410
00:15:07,410 --> 00:15:04,180
I'm still not very sure why that was the

411
00:15:09,090 --> 00:15:07,420
case because c16 and c18 obviously

412
00:15:12,690 --> 00:15:09,100
permit against es is obviously the

413
00:15:14,370 --> 00:15:12,700

highest most abundant of those of the of

414
00:15:16,650 --> 00:15:14,380
the saturated fat is all fatty acids in

415
00:15:18,720 --> 00:15:16,660
general so it was quite unusual that we

416
00:15:21,270 --> 00:15:18,730
saw this particular pattern and we're

417
00:15:22,830 --> 00:15:21,280
still not sure what caused it if you

418
00:15:24,390 --> 00:15:22,840
have any ideas like I would love to hear

419
00:15:25,830 --> 00:15:24,400
them yeah I mean just structurally I

420
00:15:26,970 --> 00:15:25,840
can't think of it especially they are

421
00:15:28,110 --> 00:15:26,980
pretty much the same all that's

422
00:15:30,150 --> 00:15:28,120
happening is that you have an additional

423
00:15:32,580 --> 00:15:30,160
methyl group at the end right sorry I -

424
00:15:33,980 --> 00:15:32,590
the two methyl groups at the end so by

425
00:15:35,720 --> 00:15:33,990
right that shouldn't be any

426
00:15:53,490 --> 00:15:35,730
friends in terms of preservation but we

427
00:15:57,220 --> 00:15:55,690
so in a few months MSL is going to

428
00:16:00,160 --> 00:15:57,230
arrive at hematite Ridge in Gale Crater

429
00:16:01,960 --> 00:16:00,170
if we see kite as part of that Ridge how

430
00:16:03,580 --> 00:16:01,970
do you think they should sample it how

431
00:16:07,830 --> 00:16:03,590
do i think they should sample it well I

432
00:16:10,630 --> 00:16:07,840
hope they don't blow it up yeah well

433
00:16:12,130 --> 00:16:10,640
that's not that's so that's so one of

434
00:16:15,430 --> 00:16:12,140
there was another thing about biomarkers

435
00:16:16,780 --> 00:16:15,440
that that was a that's a key point

436
00:16:19,000 --> 00:16:16,790
biomarkers that I didn't explain and

437
00:16:20,680 --> 00:16:19,010
that is that they should be easily and

438
00:16:23,350 --> 00:16:20,690

analyzed in the a geochemical

439
00:16:26,710 --> 00:16:23,360
environment and one of the problems is

440
00:16:28,510 --> 00:16:26,720
the way that we analyze biomarkers on

441
00:16:30,790 --> 00:16:28,520
Mars is that we tend to blow them up

442
00:16:33,190 --> 00:16:30,800
because we use thumper thermal thermal

443
00:16:34,780 --> 00:16:33,200
pyrolysis and that's actually quite a

444
00:16:36,520 --> 00:16:34,790
large problem of Mars it's the reason

445
00:16:37,660 --> 00:16:36,530
why we can't sample much of massive

446
00:16:39,790 --> 00:16:37,670
surface because of the presence of

447
00:16:42,370 --> 00:16:39,800
perchlorates or other oxidants on the

448
00:16:44,050 --> 00:16:42,380
surface because what happens is when you

449
00:16:45,970 --> 00:16:44,060
have a strong oxidant and you have

450
00:16:49,030 --> 00:16:45,980
hydrocarbons and you put them together

451
00:16:51,550 --> 00:16:49,040
and you burn them combustion occurs and

452
00:16:53,230 --> 00:16:51,560
you lose all your signals so that's

453
00:16:55,750 --> 00:16:53,240
another that's a very big problem which

454
00:16:58,120 --> 00:16:55,760
obviously I would I would like for that

455
00:17:00,310 --> 00:16:58,130
to be wet chemistry to do it but that

456
00:17:08,140 --> 00:17:00,320
may or may not be possible because bring

457
00:17:10,069 --> 00:17:08,150
solvents over to Mars etc etc all right