Maria Figueroa

Towards a Novel Planetary Biosignature: In-situ Isotopic & Elemental Analysis of Pyrite

1
00:00:00,240 --> 00:00:10,910
[Music]

2
00:00:15,600 --> 00:00:13,110
today I'm going to be talking about a

3
00:00:18,529 --> 00:00:15,610
possible new level planetary bio

4
00:00:21,329 --> 00:00:18,539
signature my you see the in situ

5
00:00:25,919 --> 00:00:21,339
isotopic and elemental analysis of

6
00:00:28,560 --> 00:00:25,929
pyrite so first I want to start out by

7
00:00:30,479 --> 00:00:28,570
talking just a little bit about Mars so

8
00:00:33,869 --> 00:00:30,489
Mars is our neighboring planet and in

9
00:00:37,349 --> 00:00:33,879
many ways is the most similar to us from

10
00:00:41,040 --> 00:00:37,359
past missions we have gotten a lot of

11
00:00:43,110 --> 00:00:41,050
evidence about how Mars was habitable in

12
00:00:46,229 --> 00:00:43,120
the past so about three to four billion

13
00:00:48,029 --> 00:00:46,239

years ago we have evidence that Mars

14
00:00:50,520 --> 00:00:48,039
could have been habitable we have

15
00:00:53,130 --> 00:00:50,530
evidence of large bodies of waters just

16
00:00:56,669 --> 00:00:53,140
flowing on Mars and it's very curious

17
00:00:58,470 --> 00:00:56,679
because at the same time period the

18
00:01:01,380 --> 00:00:58,480
earth was experiencing very similar

19
00:01:03,419 --> 00:01:01,390
conditions and we also know that during

20
00:01:05,999 --> 00:01:03,429
three to four billion years ago that's

21
00:01:09,149 --> 00:01:06,009
when light started to emerge here on

22
00:01:11,039 --> 00:01:09,159
earth so if we know that that's why one

23
00:01:14,130 --> 00:01:11,049
of the biggest questions right now is

24
00:01:17,190 --> 00:01:14,140
was there ever life on Mars that life

25
00:01:20,730 --> 00:01:17,200
ever emerged on Mars and so that's why

26
00:01:23,460 --> 00:01:20,740
the upcoming missions are seeking signs

27
00:01:26,429 --> 00:01:23,470
of past life we have for example the

28
00:01:29,429 --> 00:01:26,439
Mars 2020 Rover in the ExoMars 2020

29
00:01:33,899 --> 00:01:29,439
Rovers which main mission is to speak

30
00:01:36,569 --> 00:01:33,909
signs of past life I am very excited

31
00:01:38,510 --> 00:01:36,579
about the Mars 2020 Rover this mission

32
00:01:40,859 --> 00:01:38,520
particularly because with this mission

33
00:01:42,959 --> 00:01:40,869
we can have the upcoming mission of

34
00:01:45,120 --> 00:01:42,969
sample return and I'm very optimistic

35
00:01:47,120 --> 00:01:45,130
about that one even though we still

36
00:01:49,350 --> 00:01:47,130
don't have a launch date for that one

37
00:01:52,350 --> 00:01:49,360
but I'm optimistic that it will happen

38
00:01:55,200 --> 00:01:52,360

it will be also more get Martian samples

39
00:01:57,480 --> 00:01:55,210
here and we're gonna be able to study

40
00:01:59,340 --> 00:01:57,490
them analyze them run them through every

41
00:02:02,990 --> 00:01:59,350
single study we can and try to find out

42
00:02:05,520 --> 00:02:03,000
if there was ever life on Mars and

43
00:02:09,080 --> 00:02:05,530
besides that there are proposed future

44
00:02:12,040 --> 00:02:09,090
missions for human exploration and NASA

45
00:02:15,020 --> 00:02:12,050
ESA

46
00:02:18,230 --> 00:02:15,030
china-russia they all have put forward

47
00:02:19,700 --> 00:02:18,240
proposals for human exploration and even

48
00:02:21,470 --> 00:02:19,710
though right now it's a little bit

49
00:02:24,290 --> 00:02:21,480
controversial whether we want humans

50
00:02:26,690 --> 00:02:24,300
walking on mars given the fact that so

51
00:02:29,810 --> 00:02:26,700
many space agencies are to put forward

52
00:02:32,180 --> 00:02:29,820
humans I'm also optimistic that it will

53
00:02:34,670 --> 00:02:32,190
happen in the near future because I'm

54
00:02:37,820 --> 00:02:34,680
bringing this up because there are so

55
00:02:40,700 --> 00:02:37,830
many missions that want to find signs of

56
00:02:43,670 --> 00:02:40,710
life but what if what would be a very

57
00:02:45,230 --> 00:02:43,680
convincing evidence of life that's

58
00:02:48,080 --> 00:02:45,240
something we need to think a lot about

59
00:02:50,750 --> 00:02:48,090
and so that brings me to talk about bio

60
00:02:52,880 --> 00:02:50,760
signatures so bio signatures are

61
00:02:56,060 --> 00:02:52,890
features whose presence or abundance can

62
00:02:58,670 --> 00:02:56,070
be attributed to life this diagram right

63
00:03:02,210 --> 00:02:58,680

here was actually produced by the Mars

64
00:03:04,280 --> 00:03:02,220
2020 team when they were writing their

65
00:03:06,320 --> 00:03:04,290
proposals and they did a lot of thinking

66
00:03:08,330 --> 00:03:06,330
about what are the bio signatures that

67
00:03:10,250 --> 00:03:08,340
we want to look at when we go through

68
00:03:12,200 --> 00:03:10,260
Mars what are the bio signatures that

69
00:03:15,830 --> 00:03:12,210
will tell us something whether life was

70
00:03:16,580 --> 00:03:15,840
there or not so for example they have

71
00:03:18,680 --> 00:03:16,590
organics

72
00:03:21,590 --> 00:03:18,690
so organic molecules that are

73
00:03:24,680 --> 00:03:21,600
representative of life macro structure

74
00:03:27,620 --> 00:03:24,690
so think of fossils stromatolites are a

75
00:03:29,960 --> 00:03:27,630
great example of this chemistry so

76
00:03:33,320 --> 00:03:29,970
chemical abundance of like an element a

77
00:03:37,970 --> 00:03:33,330
molecule something that is produced by

78
00:03:40,190 --> 00:03:37,980
biological processes minerals minerals

79
00:03:44,210 --> 00:03:40,200
that are formed through direct or

80
00:03:47,840 --> 00:03:44,220
indirect processes of life micro

81
00:03:51,680 --> 00:03:47,850
structures are micro fossils so think

82
00:03:53,990 --> 00:03:51,690
about biofilms for example and isotopes

83
00:03:57,080 --> 00:03:54,000
so isotope fractionation is mainly on

84
00:04:00,980 --> 00:03:57,090
stable isotopes that are produced by

85
00:04:03,199 --> 00:04:00,990
biological processes so these are all

86
00:04:05,330 --> 00:04:03,209
good candidates for good bio signatures

87
00:04:08,720 --> 00:04:05,340
however they all have their advantages

88
00:04:10,400 --> 00:04:08,730

and disadvantages organics for example

89
00:04:12,710 --> 00:04:10,410
the problem with them is that they

90
00:04:14,780 --> 00:04:12,720
cannot be preserved for many of many

91
00:04:16,849 --> 00:04:14,790
millions of years they were thinking of

92
00:04:19,580 --> 00:04:16,859
Mars for example where we expect life to

93
00:04:22,460 --> 00:04:19,590
if it was ever there it was probably

94
00:04:25,100 --> 00:04:22,470
there 3 billion years ago or a little

95
00:04:26,960 --> 00:04:25,110
more and so it's difficult to think that

96
00:04:30,400 --> 00:04:26,970
the organics have survived there even

97
00:04:33,890 --> 00:04:30,410
with a high radiation that Mars receives

98
00:04:36,440 --> 00:04:33,900
macro structures and micro structures

99
00:04:40,340 --> 00:04:36,450
have the same problem that they're very

100
00:04:41,840 --> 00:04:40,350
acceptable to false interpretation this

101
00:04:45,650 --> 00:04:41,850
is something that nASA has suffered a

102
00:04:48,290 --> 00:04:45,660
lot from something that people should

103
00:04:50,720 --> 00:04:48,300
try not to just see a rock and

104
00:04:53,720 --> 00:04:50,730
automatically assume that it's the

105
00:04:56,990 --> 00:04:53,730
stromatolite or microbial matter and so

106
00:04:58,610 --> 00:04:57,000
forth chemistry just by looking at the

107
00:05:01,160 --> 00:04:58,620
chemistry it doesn't really tell you

108
00:05:04,910 --> 00:05:01,170
much you need to couple it with other

109
00:05:10,130 --> 00:05:04,920
types of measurements isotopes is the

110
00:05:12,680 --> 00:05:10,140
same problem minerals minerals can be

111
00:05:14,840 --> 00:05:12,690
robust because they can be preserved for

112
00:05:16,909 --> 00:05:14,850
longer times they can be preserved for

113
00:05:19,310 --> 00:05:16,919

millions and maybe billions of years

114
00:05:21,890 --> 00:05:19,320
however the problem with them is that

115
00:05:24,590 --> 00:05:21,900
most of the minerals that are formed by

116
00:05:26,780 --> 00:05:24,600
biological processes they can also be

117
00:05:29,780 --> 00:05:26,790
formed by abiotic processes and so

118
00:05:31,580 --> 00:05:29,790
they're on ambiguous in that they're

119
00:05:35,960 --> 00:05:31,590
ambiguous sorry and that creates a

120
00:05:39,860 --> 00:05:35,970
problem um however I'm an inorganic

121
00:05:41,570 --> 00:05:39,870
geochemist and I love minerals and so

122
00:05:43,219 --> 00:05:41,580
that's why I think of a lot about

123
00:05:45,830 --> 00:05:43,229
minerals that can serve as a bio

124
00:05:49,100 --> 00:05:45,840
signature and my absolute favorite

125
00:05:51,890 --> 00:05:49,110
mineral is pyrite and so that's why my

126
00:05:56,180 --> 00:05:51,900
big question is can Pirates serve as a

127
00:05:59,120 --> 00:05:56,190
bio signature so here I just want to

128
00:06:01,310 --> 00:05:59,130
explain what is pyrite specifically what

129
00:06:04,570 --> 00:06:01,320
is sedimentary pyrite say I have a

130
00:06:08,000 --> 00:06:04,580
figure here of sediments we see this

131
00:06:09,860 --> 00:06:08,010
shiny thing that looks like gold but

132
00:06:14,150 --> 00:06:09,870
it's not don't be fooled by it

133
00:06:15,830 --> 00:06:14,160
this this is pyrite this picture here is

134
00:06:17,810 --> 00:06:15,840
kind of an odd picture usually in

135
00:06:20,659 --> 00:06:17,820
sediments we get from boiled high rates

136
00:06:22,100 --> 00:06:20,669
so these are like agglomeration so if

137
00:06:22,880 --> 00:06:22,110
microcrystalline pyre is in there

138
00:06:26,270 --> 00:06:22,890

spherical

139
00:06:28,550 --> 00:06:26,280
I couldn't find a high-resolution one so

140
00:06:32,679 --> 00:06:28,560
I just put this shiny one which I also

141
00:06:35,769 --> 00:06:32,689
like anyhow so sedimentary pies there

142
00:06:38,409 --> 00:06:35,779
sulphide minerals and the way that they

143
00:06:40,899 --> 00:06:38,419
form in the waters and in sediments is

144
00:06:43,749 --> 00:06:40,909
by the help of microbial sulfate

145
00:06:45,459 --> 00:06:43,759
reduction so these microbes they take

146
00:06:49,029 --> 00:06:45,469
the sulfate and they take the organic

147
00:06:50,619 --> 00:06:49,039
matter and they metabolize it and then

148
00:06:53,649 --> 00:06:50,629
they were just two hydrogen sulfide

149
00:06:57,909 --> 00:06:53,659
which eventually can become into pyrite

150
00:07:01,709 --> 00:06:57,919
and because of this because pyrite is

151
00:07:04,869 --> 00:07:01,719
iron sulfide sulfide is reducing species

152
00:07:07,089 --> 00:07:04,879
it is stable under anoxic conditions and

153
00:07:09,850 --> 00:07:07,099
so this has a lot of implications about

154
00:07:12,790 --> 00:07:09,860
reducing potentials in marine sediments

155
00:07:15,969 --> 00:07:12,800
that's why one of the reasons why pirate

156
00:07:19,419 --> 00:07:15,979
is used a lot for paleo environmental

157
00:07:22,269 --> 00:07:19,429
proxies a really cool thing about pyrite

158
00:07:24,879 --> 00:07:22,279
is that when pirate is flora mean it can

159
00:07:26,350 --> 00:07:24,889
incorporate trace elements that are in

160
00:07:28,689 --> 00:07:26,360
its surroundings so it just incorporates

161
00:07:30,399 --> 00:07:28,699
it into its chemical structure and it

162
00:07:32,350 --> 00:07:30,409
can lock them in and so when we're

163
00:07:34,379 --> 00:07:32,360

looking at pyrite we can look at the

164
00:07:37,179 --> 00:07:34,389
trace elements and get a good idea about

165
00:07:39,309 --> 00:07:37,189
the environmental condition when that

166
00:07:42,399 --> 00:07:39,319
pirate was for me

167
00:07:43,989 --> 00:07:42,409
likewise is an iron sulfide minerals so

168
00:07:46,679 --> 00:07:43,999
there's a lot of important implications

169
00:07:49,419 --> 00:07:46,689
about the biogeochemical so first cycle

170
00:07:51,639 --> 00:07:49,429
a lot of people like to study the sulfur

171
00:07:54,399 --> 00:07:51,649
isotopes because it's very robust you

172
00:07:57,279 --> 00:07:54,409
look at the so for fractionation between

173
00:07:59,799 --> 00:07:57,289
the sulfate the source and the pyrite

174
00:08:06,639 --> 00:07:59,809
and you can get some estimate about the

175
00:08:08,769 --> 00:08:06,649
biological effect and so then again so

176
00:08:11,079 --> 00:08:08,779
my question can pirates serve as a bio

177
00:08:13,389 --> 00:08:11,089
signature so here I have again the

178
00:08:14,919 --> 00:08:13,399
diagram that I just showed you this so

179
00:08:16,600 --> 00:08:14,929
we're just gonna go over what we just

180
00:08:21,129 --> 00:08:16,610
learned about pyrite to see if it really

181
00:08:22,689 --> 00:08:21,139
works as a bio signature so we know the

182
00:08:25,389 --> 00:08:22,699
sedimentary pyrite forms through

183
00:08:27,129 --> 00:08:25,399
microbial sulfate reduction so it is a

184
00:08:29,739 --> 00:08:27,139
mineral that forms through biological

185
00:08:35,350 --> 00:08:29,749
processes so then that checks out the

186
00:08:38,889 --> 00:08:35,360
mineral box so 34s and Powerade shows

187
00:08:41,799 --> 00:08:38,899
depletion from source and this is in

188
00:08:43,020 --> 00:08:41,809

part due to biology so the sulfur

189
00:08:45,150 --> 00:08:43,030
isotopes can be Valley

190
00:08:47,250 --> 00:08:45,160
well surfer if biology helped in

191
00:08:50,430 --> 00:08:47,260
producing pyrite so that checks the

192
00:08:52,920 --> 00:08:50,440
isotope box and as we just learned trace

193
00:08:54,360 --> 00:08:52,930
elements they get incorporated into the

194
00:08:57,000 --> 00:08:54,370
pyrite and they can track the

195
00:08:59,310 --> 00:08:57,010
biogeochemical conditions and so it

196
00:09:01,830 --> 00:08:59,320
checks out the chemistry box so out of

197
00:09:04,980 --> 00:09:01,840
all of the five boxes it checks three of

198
00:09:07,770 --> 00:09:04,990
them so that is very encouraging however

199
00:09:09,720 --> 00:09:07,780
this doesn't really tell us if it works

200
00:09:12,240 --> 00:09:09,730
as a bio signature it just tells us that

201
00:09:17,760 --> 00:09:12,250
we should work hard and try to find out

202
00:09:20,970 --> 00:09:17,770
if it does however a fair warning other

203
00:09:23,640 --> 00:09:20,980
pyro formation types exist so para

204
00:09:26,670 --> 00:09:23,650
doesn't only form in sediments it forms

205
00:09:28,350 --> 00:09:26,680
in hydrothermal deposits it formed

206
00:09:30,630 --> 00:09:28,360
through igneous processes and forms

207
00:09:34,320 --> 00:09:30,640
through magmatic policies metamorphism

208
00:09:36,630 --> 00:09:34,330
and so forth many people like to tell me

209
00:09:39,330 --> 00:09:36,640
like you can just get the pirate and

210
00:09:41,250 --> 00:09:39,340
know if it's igneous or if it's the

211
00:09:45,570 --> 00:09:41,260
matter worth it and so forth that is not

212
00:09:47,579 --> 00:09:45,580
true there's there's from boydle pirate

213
00:09:50,520 --> 00:09:47,589

it's thought to be only sedimentary and

214
00:09:55,050 --> 00:09:50,530
no it forms to hydrothermal metamorphic

215
00:09:56,850 --> 00:09:55,060
and igneous processes as well um and so

216
00:09:58,530 --> 00:09:56,860
we need to be very very careful because

217
00:10:01,050 --> 00:09:58,540
we if we go to another planetary body

218
00:10:02,760 --> 00:10:01,060
and we find pyrite that's not really

219
00:10:07,350 --> 00:10:02,770
telling us anything so we need to look

220
00:10:11,850 --> 00:10:07,360
more into its chemistry and so I did a

221
00:10:14,790 --> 00:10:11,860
pilot study where I got a lot of pirate

222
00:10:16,710 --> 00:10:14,800
rings from a lot of different places on

223
00:10:19,020 --> 00:10:16,720
earth this figure here shows the

224
00:10:23,310 --> 00:10:19,030
different places where we collected this

225
00:10:25,170 --> 00:10:23,320
pirate grains and we measured the trace

226
00:10:29,630 --> 00:10:25,180
element concentrations and the sulfur

227
00:10:33,800 --> 00:10:29,640
isotopes and so I created this

228
00:10:37,020 --> 00:10:33,810
classifier that could differentiate

229
00:10:39,390 --> 00:10:37,030
pirate formation types my question was

230
00:10:44,370 --> 00:10:39,400
like could we differentiate them using a

231
00:10:46,860 --> 00:10:44,380
classifier and so currently we can just

232
00:10:48,270 --> 00:10:46,870
define what is biological and what is

233
00:10:52,020 --> 00:10:48,280
abiotic Oh

234
00:10:53,129 --> 00:10:52,030
abiotic in pirate so I try to classify

235
00:10:55,559 --> 00:10:53,139
them in turn

236
00:10:58,049 --> 00:10:55,569
formation types so try to classify them

237
00:11:11,309 --> 00:10:58,059
between sedimentary hydrothermal and

238
00:11:14,639 --> 00:11:11,319

metamorphic oh wait it's a big image

239
00:11:18,539 --> 00:11:14,649
okay so data acquisition how do I get my

240
00:11:21,470 --> 00:11:18,549
data so if we're sulfur isotopes I use

241
00:11:25,679 --> 00:11:21,480
Simms secondary ion mass spectrometer

242
00:11:28,799 --> 00:11:25,689
this is me working in Washington

243
00:11:31,879 --> 00:11:28,809
University in st. Louis and David Fikes

244
00:11:37,019 --> 00:11:31,889
lab this is the Simpson strim --nt and

245
00:11:40,889 --> 00:11:37,029
so this is all done in situ so I get the

246
00:11:44,340 --> 00:11:40,899
grains and I decide which targets I want

247
00:11:46,799 --> 00:11:44,350
to measure and so this has a laser it

248
00:11:49,799 --> 00:11:46,809
just snaps through it so this is a

249
00:11:51,689 --> 00:11:49,809
representation of what we do this is an

250
00:11:54,599 --> 00:11:51,699
80s image of a hydro thermal pressure

251
00:11:57,629 --> 00:11:54,609
rock sample the mustard color here is

252
00:12:00,179 --> 00:11:57,639
pyrite and maybe we can just look at

253
00:12:04,799 --> 00:12:00,189
this zooms in image here these black

254
00:12:06,689 --> 00:12:04,809
spots are the the spot selections where

255
00:12:09,989 --> 00:12:06,699
we sat through it and got these sulfur

256
00:12:11,999 --> 00:12:09,999
isotopes data so we always do a transect

257
00:12:14,729 --> 00:12:12,009
we do a transit because we want to see

258
00:12:16,169 --> 00:12:14,739
the evolution of the pyrite growing for

259
00:12:18,569 --> 00:12:16,179
example from here we can tell that the

260
00:12:20,100 --> 00:12:18,579
Pirates started growing here and then it

261
00:12:21,900 --> 00:12:20,110
started spreading out and so we wanted

262
00:12:25,289 --> 00:12:21,910
to track that evolution and get the

263
00:12:27,929 --> 00:12:25,299

silver eyes it's a data from it for

264
00:12:30,419 --> 00:12:27,939
trace elements in pyrite we use a very

265
00:12:33,049 --> 00:12:30,429
similar method this one is called laser

266
00:12:35,999 --> 00:12:33,059
ablation inductively coupled plasma mass

267
00:12:39,210 --> 00:12:36,009
spectrometer it works in the very

268
00:12:41,699 --> 00:12:39,220
similar fashion is also in situ it uses

269
00:12:44,069 --> 00:12:41,709
a laser as well you select the target

270
00:12:46,499 --> 00:12:44,079
spots you always want to use the same

271
00:12:47,879 --> 00:12:46,509
target spot you stop through it and then

272
00:12:51,379 --> 00:12:47,889
you get multiple trace elements

273
00:12:54,299 --> 00:12:51,389
measurements the good thing about the

274
00:12:55,170 --> 00:12:54,309
instrument that we use is that it has an

275
00:12:57,330 --> 00:12:55,180
automated

276
00:13:00,870 --> 00:12:57,340
element mapping so as you can see from

277
00:13:02,880 --> 00:13:00,880
this image here we can get the we can

278
00:13:05,430 --> 00:13:02,890
get a map of where these trace elements

279
00:13:08,580 --> 00:13:05,440
are in our sample and that's very

280
00:13:14,340 --> 00:13:08,590
helpful for trying to interpret how

281
00:13:16,770 --> 00:13:14,350
these trace elements get incorporated so

282
00:13:19,710 --> 00:13:16,780
as I mentioned I am using a statistical

283
00:13:21,420 --> 00:13:19,720
classification I use random forests

284
00:13:24,690 --> 00:13:21,430
which is a supervised machine learning

285
00:13:27,120 --> 00:13:24,700
algorithm unfortunately I don't really

286
00:13:28,980 --> 00:13:27,130
have time to explain how I do this

287
00:13:30,630 --> 00:13:28,990
classification but if anyone's

288
00:13:33,750 --> 00:13:30,640

interested in learning just let me know

289
00:13:36,720 --> 00:13:33,760
I know a really easy software that you

290
00:13:39,450 --> 00:13:36,730
don't need any data science background

291
00:13:44,280 --> 00:13:39,460
so it's really good so what we did we

292
00:13:48,510 --> 00:13:44,290
did we collect about 400 stains our

293
00:13:51,120 --> 00:13:48,520
variables we use 11 features so we use

294
00:13:54,960 --> 00:13:51,130
10 trees elements of them by essential

295
00:13:58,890 --> 00:13:54,970
elements and we use Delta 34 s as the

296
00:14:01,710 --> 00:13:58,900
isotope our classification I trained the

297
00:14:03,540 --> 00:14:01,720
classifier to distinguish between

298
00:14:06,540 --> 00:14:03,550
information types so sedimentary

299
00:14:08,550 --> 00:14:06,550
hydrothermal metamorphic this is an

300
00:14:10,740 --> 00:14:08,560
example of one of the experiments that I

301
00:14:13,590 --> 00:14:10,750
made this is only one decision tree out

302
00:14:16,740 --> 00:14:13,600
of the 500 that I usually do and it just

303
00:14:20,090 --> 00:14:16,750
shows how it how the tree branches

304
00:14:22,740 --> 00:14:20,100
itself as it starts as it starts

305
00:14:25,980 --> 00:14:22,750
classifying them into their distinguish

306
00:14:32,340 --> 00:14:25,990
formation type so these are the results

307
00:14:36,090 --> 00:14:32,350
from a pilot study so I here I'm showing

308
00:14:38,220 --> 00:14:36,100
three different experiments the first

309
00:14:40,190 --> 00:14:38,230
one was only looking at trace elements

310
00:14:42,540 --> 00:14:40,200
without looking at sulfur isotopes

311
00:14:44,940 --> 00:14:42,550
second one was only looking at sulfur

312
00:14:46,590 --> 00:14:44,950
isotopes without trace elements and the

313
00:14:49,350 --> 00:14:46,600

third one looking at trace elements and

314
00:14:52,740 --> 00:14:49,360
sulfur isotopes together what we're in

315
00:14:54,150 --> 00:14:52,750
here are a confusion matrices and yeah

316
00:14:56,520 --> 00:14:54,160
we're pretty confusing and so we're not

317
00:14:59,580 --> 00:14:56,530
going to go over them now but what I

318
00:15:03,570 --> 00:14:59,590
want you guys to notice is the accuracy

319
00:15:05,760 --> 00:15:03,580
of them so what we can see is that when

320
00:15:07,000 --> 00:15:05,770
we coupled both trace elements and

321
00:15:10,480 --> 00:15:07,010
sulfur isotopes together

322
00:15:13,180 --> 00:15:10,490
is when we get the highest accuracy so

323
00:15:15,250 --> 00:15:13,190
that's very encouraging however for the

324
00:15:18,819 --> 00:15:15,260
sulfur isotopes the Icarus II was fairly

325
00:15:21,009 --> 00:15:18,829
low and things of course makes sense if

326
00:15:23,350 --> 00:15:21,019
you go back to Becky's talk when she was

327
00:15:26,319 --> 00:15:23,360
talking about like geologic time scale

328
00:15:28,120 --> 00:15:26,329
and all the different the different

329
00:15:30,180 --> 00:15:28,130
chemistry that existed throughout time

330
00:15:33,519 --> 00:15:30,190
it does make sense that sulfur isotopes

331
00:15:35,889 --> 00:15:33,529
will vary like thing I forgot to mention

332
00:15:37,720 --> 00:15:35,899
but my pirate grades third throughout

333
00:15:40,689 --> 00:15:37,730
geologic time so I have from the our

334
00:15:43,090 --> 00:15:40,699
camp Proterra soy vanilla throughout all

335
00:15:45,579 --> 00:15:43,100
of geologic time so of course they will

336
00:15:49,150 --> 00:15:45,589
bury however traits elements they did a

337
00:15:51,129 --> 00:15:49,160
very good job and we were surprised this

338
00:15:53,460 --> 00:15:51,139

we really didn't understand why he was

339
00:15:56,350 --> 00:15:53,470
doing such a great job so moving forward

340
00:15:59,019 --> 00:15:56,360
these are all Asian samples we wanted to

341
00:16:01,600 --> 00:15:59,029
really understand how it is that trace

342
00:16:03,400 --> 00:16:01,610
elements in sulfur isotopes how they get

343
00:16:06,519 --> 00:16:03,410
incorporated into pirate and not only

344
00:16:11,319 --> 00:16:06,529
that but how diagenesis affect that

345
00:16:14,850 --> 00:16:11,329
original signature and so that is what

346
00:16:17,920 --> 00:16:14,860
we're doing now we I am collecting

347
00:16:20,199 --> 00:16:17,930
samples from all of these sites the ones

348
00:16:22,449 --> 00:16:20,209
in greens are sites that I've already

349
00:16:25,530 --> 00:16:22,459
collected samples from the ones in red

350
00:16:28,509 --> 00:16:25,540
are the ones that I still have to go to

351
00:16:31,379 --> 00:16:28,519
Black Sea is the classic extended site

352
00:16:35,110 --> 00:16:31,389
there's a lot of studies on this area

353
00:16:39,189 --> 00:16:35,120
Santa Monica Basin in California it's a

354
00:16:41,410 --> 00:16:39,199
seasonally variable water column and so

355
00:16:44,340 --> 00:16:41,420
there's a lot of pollen there's an

356
00:16:47,680 --> 00:16:44,350
oxygen minimum zone is a very dynamic

357
00:16:50,920 --> 00:16:47,690
continental margin I did a lot of work

358
00:16:53,100 --> 00:16:50,930
here trying to get pyrite and it turns

359
00:16:55,629 --> 00:16:53,110
out that there's this very amazing

360
00:16:58,240 --> 00:16:55,639
cryptic sylph recycling happening there

361
00:17:01,150 --> 00:16:58,250
that's a sulfate gets reduced to sulfide

362
00:17:02,860 --> 00:17:01,160
and immediately gets oxidized back so he

363
00:17:06,220 --> 00:17:02,870

didn't really get any hiring out of it

364
00:17:10,510 --> 00:17:06,230
but it became a very interesting project

365
00:17:15,220 --> 00:17:10,520
about critics over cycles from Saanich

366
00:17:17,500 --> 00:17:15,230
Inlet is an anoxic seasonal Basin that I

367
00:17:18,660 --> 00:17:17,510
visited Effingham is sick cynic and for

368
00:17:22,230 --> 00:17:18,670
Miss oxic

369
00:17:24,690 --> 00:17:22,240
I was at sandwich English I just came

370
00:17:27,780 --> 00:17:24,700
back about two weeks ago I was doing

371
00:17:29,970 --> 00:17:27,790
field work there it was a lot of fun it

372
00:17:33,690 --> 00:17:29,980
was a great experience

373
00:17:37,200 --> 00:17:33,700
we collected anoxic sediments as we can

374
00:17:40,650 --> 00:17:37,210
see here this is really gooey sediments

375
00:17:44,070 --> 00:17:40,660
and really black and they had this very

376
00:17:46,200 --> 00:17:44,080
rich like rotten egg smell to it so

377
00:17:49,020 --> 00:17:46,210
there's a lot of silt by in here which

378
00:17:51,270 --> 00:17:49,030
is great unlike my son of Monica Basin

379
00:17:54,720 --> 00:17:51,280
sediments which smell like nothing so uh

380
00:17:56,130 --> 00:17:54,730
it's very encouraging to to find pyrite

381
00:17:58,440 --> 00:17:56,140
here there should be a lot of pirate

382
00:18:02,130 --> 00:17:58,450
here because it's very anoxic and this

383
00:18:03,570 --> 00:18:02,140
is how I how I extracted the sediment so

384
00:18:06,690 --> 00:18:03,580
these are anoxic they need to be

385
00:18:08,790 --> 00:18:06,700
extracted in a glow bag perch with

386
00:18:10,530 --> 00:18:08,800
nitrogen gas so they don't come in

387
00:18:13,740 --> 00:18:10,540
contact with oxygen because once they do

388
00:18:21,140 --> 00:18:13,750

they get they get oxidized and the

389
00:18:23,100 --> 00:18:21,150
chemistry will change Megan okay so I

390
00:18:26,130 --> 00:18:23,110
just came back so I don't really have

391
00:18:29,190 --> 00:18:26,140
any data to show you about that but I do

392
00:18:30,960 --> 00:18:29,200
have my methods of what I plan to do so

393
00:18:34,950 --> 00:18:30,970
now I have my sentiments I also

394
00:18:38,160 --> 00:18:34,960
collected bottom water bottom waters

395
00:18:41,000 --> 00:18:38,170
from it so I have waters that I'm gonna

396
00:18:44,640 --> 00:18:41,010
study the trace elements as well as

397
00:18:46,560 --> 00:18:44,650
sulfur I have the sediments poor waters

398
00:18:48,390 --> 00:18:46,570
from the side of man some or all of them

399
00:18:50,850 --> 00:18:48,400
I'm gonna study the trace elements in

400
00:18:52,320 --> 00:18:50,860
sulfur and then I'm gonna extract the

401
00:18:54,060 --> 00:18:52,330
pirate from it and I'm gonna do

402
00:18:57,390 --> 00:18:54,070
something similar to this image here

403
00:18:58,920 --> 00:18:57,400
which I'm gonna do a transect and look

404
00:19:02,520 --> 00:18:58,930
at the trace elements and sulfur

405
00:19:04,460 --> 00:19:02,530
isotopes in situ to see what it tells us

406
00:19:07,020 --> 00:19:04,470
and we have done this in the past

407
00:19:10,680 --> 00:19:07,030
pyrite grains and it's really hard to

408
00:19:12,720 --> 00:19:10,690
make any assumption try to come with any

409
00:19:15,060 --> 00:19:12,730
interpretation on it and that's why I

410
00:19:17,250 --> 00:19:15,070
want to do modern because in modern I

411
00:19:19,640 --> 00:19:17,260
can look at the sediments the poor

412
00:19:22,650 --> 00:19:19,650
fluids the waters and really understand

413
00:19:25,800 --> 00:19:22,660

what is the relationship between all of

414
00:19:26,780 --> 00:19:25,810
that and between the pyrite grains and I

415
00:19:30,230 --> 00:19:26,790
think I'm out of

416
00:19:32,560 --> 00:19:30,240
so here's thank you to everyone that has

417
00:19:34,920 --> 00:19:32,570
helped me all the funding agencies and

418
00:19:39,040 --> 00:19:34,930
open to questions

419
00:19:48,550 --> 00:19:39,050
[Applause]

420
00:19:53,720 --> 00:19:51,380
first of all thank you for your very

421
00:19:56,750 --> 00:19:53,730
recent talk so my question is more a

422
00:19:59,120 --> 00:19:56,760
curiosity and the pirated is form

423
00:20:01,220 --> 00:19:59,130
pyrogen Italy is possible to find

424
00:20:05,420 --> 00:20:01,230
organic matter there that could be used

425
00:20:10,430 --> 00:20:05,430
to further assess that biodiversity so

426
00:20:13,460 --> 00:20:10,440
yes but it's mostly in very modern pie

427
00:20:16,910 --> 00:20:13,470
right once it goes through diagenesis it

428
00:20:19,190 --> 00:20:16,920
starts to lose that shield of organic

429
00:20:20,840 --> 00:20:19,200
material so that's why I'm not even

430
00:20:23,690 --> 00:20:20,850
looking at organic material because I am

431
00:20:27,890 --> 00:20:23,700
curious about the diagenesis and how it

432
00:20:29,540 --> 00:20:27,900
gets preserved and I just had a quick

433
00:20:31,580 --> 00:20:29,550
question so when you were looking at

434
00:20:33,560 --> 00:20:31,590
like the accuracy of the various ones

435
00:20:35,810 --> 00:20:33,570
that look like the metamorphic was like

436
00:20:38,030 --> 00:20:35,820
really good for all of them yeah versus

437
00:20:39,740 --> 00:20:38,040
the other is there a reason why that's

438
00:20:43,070 --> 00:20:39,750

more accurate there definitely is the

439
00:20:45,620 --> 00:20:43,080
reason so during metamorphic processes

440
00:20:48,520 --> 00:20:45,630
you can think of like magmatic processes

441
00:20:51,230 --> 00:20:48,530
for example when the pirate is four mean

442
00:20:54,500 --> 00:20:51,240
it's taking out all of the trace

443
00:20:57,070 --> 00:20:54,510
elements that were before so it has very

444
00:21:00,020 --> 00:20:57,080
very low amounts of trace elements about

445
00:21:03,100 --> 00:21:00,030
parts per trillion of trace element so

446
00:21:07,190 --> 00:21:03,110
that's why it's very good on just like

447
00:21:08,850 --> 00:21:07,200
telling that one apart alright let's