1
00:00:06,389 --> 00:00:03,590
hello everybody um welcome

2
00:00:07,749 --> 00:00:06,399
my name is adrian bros um i'm glad that

3
00:00:09,669 --> 00:00:07,759
you're all here today

4
00:00:11,509 --> 00:00:09,679
um today i'm going to be talking to you

5
00:00:13,350 --> 00:00:11,519
about um

6
00:00:14,950 --> 00:00:13,360
the potential preservation of

7
00:00:17,430 --> 00:00:14,960
biosignatures in

8
00:00:20,390 --> 00:00:17,440
some of earth's earliest soils also

9
00:00:22,950 --> 00:00:20,400
known as paleosols

10
00:00:24,710 --> 00:00:22,960
and so on the menu for today we're

11
00:00:26,390 --> 00:00:24,720
broadly discussing two research

12
00:00:28,230 --> 00:00:26,400
questions so for one

13
00:00:31,109 --> 00:00:28,240

are there signatures of life preserved

14
00:00:32,870 --> 00:00:31,119
in earth's earliest soils

15
00:00:34,229 --> 00:00:32,880
and second are these soils rich in

16
00:00:36,790 --> 00:00:34,239
sulfur like uh

17
00:00:37,830 --> 00:00:36,800
rocks on mars and so we're going to take

18
00:00:39,990 --> 00:00:37,840
a series

19
00:00:41,350 --> 00:00:40,000
of two different field studies we're

20
00:00:42,869 --> 00:00:41,360
going to first look at archaean

21
00:00:44,630 --> 00:00:42,879
three billion year old acid sulfate

22
00:00:45,750 --> 00:00:44,640
paleosol from australia and the feral

23
00:00:47,590 --> 00:00:45,760
quartzite

24
00:00:49,510 --> 00:00:47,600
and then we'll move to an archaean acid

25
00:00:52,150 --> 00:00:49,520
sulfate uh paleocell from

26
00:00:53,910 --> 00:00:52,160
greenland that appears to be about 3.7

27
00:00:56,950 --> 00:00:53,920
billion years old from the isola

28
00:00:59,430 --> 00:00:56,960
supercrustal belt so

29
00:01:01,110 --> 00:00:59,440
more broadly and to take a step back um

30
00:01:03,270 --> 00:01:01,120
why are we doing this work so

31
00:01:05,670 --> 00:01:03,280
um for one we want to understand uh

32
00:01:07,590 --> 00:01:05,680
should putative paleocells on mars be

33
00:01:08,710 --> 00:01:07,600
targeted for future exploration whether

34
00:01:11,270 --> 00:01:08,720
that's for

35
00:01:12,870 --> 00:01:11,280
biosignature investigation or for mars

36
00:01:14,390 --> 00:01:12,880
sample return

37
00:01:16,630 --> 00:01:14,400
and specifically we want to understand

38
00:01:18,469 --> 00:01:16,640

well do these archaean age paleocells

39
00:01:19,670 --> 00:01:18,479
from earth preserve detectable organic

40
00:01:21,510 --> 00:01:19,680
carbon

41
00:01:23,429 --> 00:01:21,520
and second is the preservation of

42
00:01:26,550 --> 00:01:23,439
organic carbon related to the sulfur

43
00:01:28,550 --> 00:01:26,560
content of paleozoics so to begin

44
00:01:29,990 --> 00:01:28,560
also to take a step back what is a paleo

45
00:01:33,270 --> 00:01:30,000
salt

46
00:01:35,990 --> 00:01:33,280
well it is a buried fossilized

47
00:01:38,710 --> 00:01:36,000
surface environment or soil which is now

48
00:01:41,510 --> 00:01:38,720
lithified into a sedimentary rock

49
00:01:43,109 --> 00:01:41,520
and most commonly paleocells form from

50
00:01:45,270 --> 00:01:43,119
rapid burial

51
00:01:46,149 --> 00:01:45,280
whether that be from volcanoes

52
00:01:48,950 --> 00:01:46,159
landslides

53
00:01:51,190 --> 00:01:48,960
dust storms sedimentation from flooding

54
00:01:53,270 --> 00:01:51,200
ash and tough deposits which cap and

55
00:01:55,510 --> 00:01:53,280
bury the soil

56
00:01:57,590 --> 00:01:55,520
and here we can see here sort of an

57
00:01:59,670 --> 00:01:57,600
anthropocene on the left version of a

58
00:02:02,469 --> 00:01:59,680
paleocell being created in real time by

59
00:02:03,590 --> 00:02:02,479
a uh by a lava flow on the big island of

60
00:02:06,230 --> 00:02:03,600
hawaii

61
00:02:07,990 --> 00:02:06,240
and then sort of on the right a um a

62
00:02:11,029 --> 00:02:08,000
paleo version of this

63
00:02:12,949 --> 00:02:11,039

burial event which is burying the soil

64
00:02:14,949 --> 00:02:12,959
this is on the right of myocene age

65
00:02:16,309 --> 00:02:14,959
intra basaltic paleo saw this red layer

66
00:02:17,990 --> 00:02:16,319
here

67
00:02:20,830 --> 00:02:18,000
and that has been buried by flood

68
00:02:23,270 --> 00:02:20,840
basalts from the columbia river

69
00:02:24,550 --> 00:02:23,280
basalt so uh

70
00:02:25,750 --> 00:02:24,560
how do we recognize paleocells in the

71
00:02:27,990 --> 00:02:25,760
field well there's a couple different

72
00:02:30,229 --> 00:02:28,000
ways morphologically

73
00:02:32,309 --> 00:02:30,239
most often they have a what's called a

74
00:02:33,190 --> 00:02:32,319
sharp top which is the burial layer or

75
00:02:35,030 --> 00:02:33,200
the cap

76
00:02:36,550 --> 00:02:35,040
and this most often in the case of

77
00:02:38,070 --> 00:02:36,560
sedimentation from flooding as the

78
00:02:41,030 --> 00:02:38,080
burial mechanism

79
00:02:41,509 --> 00:02:41,040
leads to cross bedding which is then

80
00:02:43,910 --> 00:02:41,519
capping

81
00:02:45,670 --> 00:02:43,920
you can see the underlying bed here that

82
00:02:47,589 --> 00:02:45,680
this destruction of bedding

83
00:02:49,270 --> 00:02:47,599
which is characteristic of bioturbation

84
00:02:50,949 --> 00:02:49,280
and pedoturbation during

85
00:02:52,630 --> 00:02:50,959
soil development it just kind of

86
00:02:55,990 --> 00:02:52,640
destroys that original

87
00:03:00,229 --> 00:02:58,149
and so the fossil record of soils is uh

88
00:03:02,309 --> 00:03:00,239

from on earth from the archaean to the

89
00:03:04,070 --> 00:03:02,319
holocene and everywhere in between

90
00:03:05,670 --> 00:03:04,080
on the left here we can see a pleisocene

91
00:03:08,470 --> 00:03:05,680
age buried

92
00:03:09,830 --> 00:03:08,480
molosol here this black layer which is

93
00:03:12,390 --> 00:03:09,840
buried by approximately

94
00:03:14,070 --> 00:03:12,400
two or three meters of less um and on

95
00:03:16,229 --> 00:03:14,080
the right we can see

96
00:03:17,350 --> 00:03:16,239
a potential paleosol from greenland

97
00:03:17,990 --> 00:03:17,360
we'll be looking a little bit more on

98
00:03:20,790 --> 00:03:18,000
this one in this

99
00:03:21,910 --> 00:03:20,800
talk that has a burial cap up here and

100
00:03:23,990 --> 00:03:21,920
then a series of

101
00:03:25,030 --> 00:03:24,000
diffuse horizons which are a common

102
00:03:28,630 --> 00:03:25,040
characteristic

103
00:03:30,149 --> 00:03:28,640
of soils and our rationale for studying

104
00:03:30,869 --> 00:03:30,159
pillar cells on earth that are really

105
00:03:33,110 --> 00:03:30,879
old

106
00:03:35,509 --> 00:03:33,120
is that our key in age ones from about

107
00:03:37,589 --> 00:03:35,519
2.6 to 2.7 billion years

108
00:03:39,430 --> 00:03:37,599
preserve biogenic organic carbon

109
00:03:41,430 --> 00:03:39,440
probably derived from cyanobacterial

110
00:03:43,030 --> 00:03:41,440
mats

111
00:03:45,190 --> 00:03:43,040
second there's mounting evidence of

112
00:03:46,949 --> 00:03:45,200
widespread surface weathering leading to

113
00:03:50,070 --> 00:03:46,959

pedogenic weathering

114
00:03:51,910 --> 00:03:50,080
on mars billions of years ago and

115
00:03:53,030 --> 00:03:51,920
third paleo cells have recently been

116
00:03:55,110 --> 00:03:53,040
named a high priority site for

117
00:03:59,030 --> 00:03:55,120
biosignature detection and

118
00:04:01,750 --> 00:03:59,040
mars sample return and so why paleo

119
00:04:03,429 --> 00:04:01,760
is on mars well based on all the

120
00:04:04,149 --> 00:04:03,439
mineralogical and remote sensing

121
00:04:06,229 --> 00:04:04,159
evidence

122
00:04:08,149 --> 00:04:06,239
it's possible that at gale crater

123
00:04:11,990 --> 00:04:08,159
curiosity could encounter

124
00:04:13,270 --> 00:04:12,000
a paleosol similarly at the nowakian age

125
00:04:14,949 --> 00:04:13,280
jezreel crater

126
00:04:16,629 --> 00:04:14,959
on this pelia lake with an extensive

127
00:04:19,110 --> 00:04:16,639
delta system where perseverance

128
00:04:21,270 --> 00:04:19,120
landed last february there's on the

129
00:04:22,629 --> 00:04:21,280
western delta and sort of the northern

130
00:04:25,830 --> 00:04:22,639
fan there's these ubiquitous and

131
00:04:28,390 --> 00:04:25,840
widespread dioctahedral aluminum clay

132
00:04:29,909 --> 00:04:28,400
and silica deposits that are associated

133
00:04:32,070 --> 00:04:29,919
with these point bar

134
00:04:35,430 --> 00:04:32,080
settings which suggest surface

135
00:04:36,790 --> 00:04:35,440
weathering or the presence of pele saws

136
00:04:39,270 --> 00:04:36,800
we know so much about the surface of

137
00:04:39,909 --> 00:04:39,280
mars because of our orbital remote

138
00:04:41,430 --> 00:04:39,919

sensing

139
00:04:43,030 --> 00:04:41,440
primarily in the visible and near

140
00:04:46,070 --> 00:04:43,040
infrared range

141
00:04:47,270 --> 00:04:46,080
which across nowakian age terrains on

142
00:04:49,030 --> 00:04:47,280
mars has

143
00:04:52,230 --> 00:04:49,040
really detected in thousands of

144
00:04:55,110 --> 00:04:52,240
locations diohedral aluminum and iron

145
00:04:55,749 --> 00:04:55,120
magnesium clays that are associated with

146
00:04:58,790 --> 00:04:55,759
formation

147
00:05:01,110 --> 00:04:58,800
in pedogenic or soil settings and when

148
00:05:04,070 --> 00:05:01,120
you overlay stratigraphy on top

149
00:05:05,670 --> 00:05:04,080
of these mineralogical maps by

150
00:05:06,629 --> 00:05:05,680
overlaying the mineralogy with a digital

151
00:05:08,710 --> 00:05:06,639
elevation model

152
00:05:10,310 --> 00:05:08,720
we can see that these there's this

153
00:05:12,310 --> 00:05:10,320
pedogenic pedogenic-like stratigraphy

154
00:05:13,830 --> 00:05:12,320
where aluminum clays overly iron and

155
00:05:16,310 --> 00:05:13,840
magnesium clays

156
00:05:17,350 --> 00:05:16,320
and they're all uh nowakin in age 3.7

157
00:05:20,629 --> 00:05:17,360
billion years

158
00:05:22,870 --> 00:05:20,639
and older so we know so much about the

159
00:05:25,270 --> 00:05:22,880
surface of mars in situ because of the

160
00:05:27,110 --> 00:05:25,280
sample analysis of mars sam instrument

161
00:05:29,029 --> 00:05:27,120
which the goal is to assess the passive

162
00:05:30,390 --> 00:05:29,039
ability and isotopic

163
00:05:32,550 --> 00:05:30,400

composition of the surface in the

164
00:05:34,230 --> 00:05:32,560
atmosphere and this is one of the

165
00:05:36,150 --> 00:05:34,240
instruments we use to characterize the

166
00:05:37,510 --> 00:05:36,160
archaean paleocells so we'll get into

167
00:05:38,310 --> 00:05:37,520
talking about it in our methods in a

168
00:05:40,629 --> 00:05:38,320
minute

169
00:05:42,629 --> 00:05:40,639
but it operates largely in two modes sam

170
00:05:45,029 --> 00:05:42,639
ega mode which detects both gases and

171
00:05:46,790 --> 00:05:45,039
same gcms mode which detects

172
00:05:48,790 --> 00:05:46,800
through molecular separation uh

173
00:05:50,070 --> 00:05:48,800
individual organic molecules

174
00:05:52,790 --> 00:05:50,080
but here we're only going to run it in

175
00:05:55,430 --> 00:05:52,800
same ega mode to look at our archaean

176
00:05:57,510 --> 00:05:55,440
paleosols for the first time

177
00:05:58,870 --> 00:05:57,520
and so with this instrument sam onboard

178
00:06:02,309 --> 00:05:58,880
curiosity

179
00:06:04,870 --> 00:06:02,319
organic carbon has been detected in

180
00:06:06,710 --> 00:06:04,880
association with uh with sulfur so

181
00:06:09,110 --> 00:06:06,720
either through sulfurization reactions

182
00:06:11,670 --> 00:06:09,120
which cross link and stabilize

183
00:06:13,189 --> 00:06:11,680
um different forms of organic carbon

184
00:06:13,590 --> 00:06:13,199
which in this case look to be carrigen

185
00:06:16,790 --> 00:06:13,600
like

186
00:06:19,270 --> 00:06:16,800
up to 10 parts per million or

187
00:06:20,629 --> 00:06:19,280
it's locked up in the crystal structure

188
00:06:22,469 --> 00:06:20,639

in the crystal lattice of sulfate

189
00:06:25,990 --> 00:06:22,479
minerals like gypsum basin

190
00:06:27,990 --> 00:06:26,000
bassinite and pyrite and so

191
00:06:29,749 --> 00:06:28,000
uh it's thought that sulfur through

192
00:06:32,070 --> 00:06:29,759
either sulfurization or

193
00:06:33,270 --> 00:06:32,080
or reactions with mineral surfaces or

194
00:06:36,150 --> 00:06:33,280
locking in

195
00:06:37,189 --> 00:06:36,160
sulfate minerals it's sulfur has aided

196
00:06:39,270 --> 00:06:37,199
in the preservation

197
00:06:41,029 --> 00:06:39,280
of organic matter on mars for billions

198
00:06:43,510 --> 00:06:41,039
of years

199
00:06:45,510 --> 00:06:43,520
and so on earth we see evidence both in

200
00:06:47,590 --> 00:06:45,520
geochemistry and morphology

201
00:06:49,670 --> 00:06:47,600
of ancient rocks and sediments that uh

202
00:06:51,430 --> 00:06:49,680
we might have had some undergoing

203
00:06:54,550 --> 00:06:51,440
acid sulfate weathering on the surface

204
00:06:57,749 --> 00:06:54,560
of early earth like on mars

205
00:07:00,629 --> 00:06:57,759
and so for this work we will first

206
00:07:02,150 --> 00:07:00,639
compile the previously published

207
00:07:04,150 --> 00:07:02,160
observations of archaean paleosols

208
00:07:06,469 --> 00:07:04,160
including total organic carbon

209
00:07:07,990 --> 00:07:06,479
and both geochemistry we then performed

210
00:07:10,150 --> 00:07:08,000
a sam ega analysis

211
00:07:11,110 --> 00:07:10,160
on a greenland paleosol to look at the

212
00:07:13,510 --> 00:07:11,120
influence of

213
00:07:14,550 --> 00:07:13,520

mineralogy on total organic carbon and

214
00:07:16,309 --> 00:07:14,560
then we

215
00:07:18,070 --> 00:07:16,319
related in the australian palette i saw

216
00:07:20,230 --> 00:07:18,080
total organocarbon with a number of

217
00:07:23,029 --> 00:07:20,240
pyrite framboids

218
00:07:24,790 --> 00:07:23,039
so that's sort of a metric of of of the

219
00:07:26,870 --> 00:07:24,800
sulfate content or the ancient sulfur

220
00:07:28,870 --> 00:07:26,880
content of these soils

221
00:07:31,350 --> 00:07:28,880
so the sam ej instrument works like this

222
00:07:34,550 --> 00:07:31,360
it heats our sample up in an oven

223
00:07:36,309 --> 00:07:34,560
here and here to about

224
00:07:38,469 --> 00:07:36,319
900 degrees centigrade and the sample

225
00:07:40,070 --> 00:07:38,479
decomposes into volatile gases

226
00:07:42,309 --> 00:07:40,080
those gases get sucked into a mass

227
00:07:44,070 --> 00:07:42,319
spectrometer and identified based on

228
00:07:45,749 --> 00:07:44,080
their mass charge ratio

229
00:07:47,350 --> 00:07:45,759
this constrains mineralogy and carbon

230
00:07:49,670 --> 00:07:47,360
content to the samples

231
00:07:51,670 --> 00:07:49,680
and without the need for any harsh acid

232
00:07:53,029 --> 00:07:51,680
pre-treatment to remove any inorganic

233
00:07:55,270 --> 00:07:53,039
carbonates

234
00:07:56,869 --> 00:07:55,280
so here's the greenland soil it's a

235
00:07:59,749 --> 00:07:56,879
potential

236
00:08:02,309 --> 00:07:59,759
3.7 billion year old acid sulfate paleo

237
00:08:05,589 --> 00:08:02,319
salt based on its geochemistry

238
00:08:07,749 --> 00:08:05,599

and its morphology and so we took this

239
00:08:09,110 --> 00:08:07,759
sample and ground it down and subjected

240
00:08:12,710 --> 00:08:09,120
it to

241
00:08:13,510 --> 00:08:12,720
total organocarbon and isotopic dell 13c

242
00:08:16,550 --> 00:08:13,520
analysis

243
00:08:18,550 --> 00:08:16,560
so stable carbon isotopes and we can see

244
00:08:20,629 --> 00:08:18,560
here with depth there's this marked

245
00:08:23,110 --> 00:08:20,639
increase both in total organic carbon

246
00:08:24,390 --> 00:08:23,120
which was remarkably high up to 1.6

247
00:08:27,270 --> 00:08:24,400
weight percent

248
00:08:28,469 --> 00:08:27,280
and dell 13c ranging between 24 to 27

249
00:08:30,230 --> 00:08:28,479
per ml

250
00:08:31,990 --> 00:08:30,240
with slight rayleigh distillation at the

251
00:08:32,790 --> 00:08:32,000
surface which is a common feature in

252
00:08:36,709 --> 00:08:32,800
soils

253
00:08:39,829 --> 00:08:36,719
decomposition of organic matter in the

254
00:08:41,110 --> 00:08:39,839
surface enriched horizons

255
00:08:43,430 --> 00:08:41,120
and so we can see some really

256
00:08:46,870 --> 00:08:43,440
interesting trends here with our

257
00:08:48,310 --> 00:08:46,880
evolved gas analysis so on the y-axis is

258
00:08:50,710 --> 00:08:48,320
co2 ion current and

259
00:08:52,550 --> 00:08:50,720
so2 ion current here in the yellow and

260
00:08:53,509 --> 00:08:52,560
red respectively on the x-axis is

261
00:08:55,829 --> 00:08:53,519
temperature

262
00:08:57,670 --> 00:08:55,839
and on this second y-axis we can see we

263
00:08:59,110 --> 00:08:57,680

have heat flow the dotted line here so

264
00:09:00,630 --> 00:08:59,120
this is uh telling us whether we have an

265
00:09:03,509 --> 00:09:00,640
endothermic reaction

266
00:09:05,430 --> 00:09:03,519
or an exothermic reaction and so at

267
00:09:08,790 --> 00:09:05,440
around 400 c we see this big

268
00:09:12,070 --> 00:09:08,800
burst of co2 this big release of uh

269
00:09:15,509 --> 00:09:12,080
probably organic carbon which is

270
00:09:17,030 --> 00:09:15,519
accompanied by a slight sulfur so2 peak

271
00:09:19,750 --> 00:09:17,040
here

272
00:09:21,190 --> 00:09:19,760
but most notably we also have a

273
00:09:23,190 --> 00:09:21,200
potentially what looks to be a carriage

274
00:09:25,750 --> 00:09:23,200
in peak so much higher temperature

275
00:09:26,949 --> 00:09:25,760
much more thermally stable peak

276
00:09:30,070 --> 00:09:26,959
accompanied by a

277
00:09:31,750 --> 00:09:30,080
large exothermic heat release here

278
00:09:34,150 --> 00:09:31,760
and this is characteristic of organic

279
00:09:35,350 --> 00:09:34,160
carbon decomposition

280
00:09:37,670 --> 00:09:35,360
so this are either from mineral

281
00:09:39,350 --> 00:09:37,680
associated carbon kerogen compounds or

282
00:09:41,590 --> 00:09:39,360
as we can see here tailing off with a

283
00:09:43,670 --> 00:09:41,600
co2 release at really high temperature

284
00:09:46,310 --> 00:09:43,680
around 900 degrees centigrade organo

285
00:09:48,870 --> 00:09:46,320
sulfur compounds

286
00:09:49,990 --> 00:09:48,880
and so um yeah we have yeah trying to

287
00:09:52,710 --> 00:09:50,000
still figure out what this all

288
00:09:55,030 --> 00:09:52,720

means but it looks to be like there is

289
00:09:57,670 --> 00:09:55,040
potentially some preserved organo sulfur

290
00:09:59,829 --> 00:09:57,680
compounds in these ancient soils

291
00:10:01,430 --> 00:09:59,839
and so we're not sure what the source of

292
00:10:01,990 --> 00:10:01,440
those is at this point so we can't rule

293
00:10:04,710 --> 00:10:02,000
them

294
00:10:06,710 --> 00:10:04,720
as being biogenic or abiogenic but

295
00:10:07,990 --> 00:10:06,720
moving on now to the second soil

296
00:10:11,030 --> 00:10:08,000
shifting gears a little bit towards

297
00:10:13,829 --> 00:10:11,040
australia we're looking now at a 3.0

298
00:10:15,350 --> 00:10:13,839
potential acid sulfate halisal from a

299
00:10:19,190 --> 00:10:15,360
feral quartzite

300
00:10:22,630 --> 00:10:19,200
in the pilbara craton in australia

301
00:10:23,990 --> 00:10:22,640
and morphologically these profiles look

302
00:10:27,829 --> 00:10:24,000
really similar to

303
00:10:30,870 --> 00:10:27,839
uh soil profiles in modern times

304
00:10:32,470 --> 00:10:30,880
especially acid sulfate soils and so we

305
00:10:35,269 --> 00:10:32,480
measured here on the right

306
00:10:37,110 --> 00:10:35,279
um total organic carbon as a function of

307
00:10:40,310 --> 00:10:37,120
depth

308
00:10:41,110 --> 00:10:40,320
and we uh previous work has shown the

309
00:10:42,630 --> 00:10:41,120
presence

310
00:10:45,190 --> 00:10:42,640
through thin sections on the there are

311
00:10:47,350 --> 00:10:45,200
these carbonaceous microfossils

312
00:10:48,870 --> 00:10:47,360
which have been embassaged to be things

313
00:10:49,910 --> 00:10:48,880

like a terrestrial community of bacteria

314
00:10:55,590 --> 00:10:49,920
bacteria and

315
00:10:57,030 --> 00:10:55,600
methanogenic archaea

316
00:10:58,710 --> 00:10:57,040
also in these samples there is

317
00:11:01,750 --> 00:10:58,720
framboidal pyrite

318
00:11:04,230 --> 00:11:01,760
in abundance so this is the iron sulfate

319
00:11:04,790 --> 00:11:04,240
mineral it's framboidal which is sort of

320
00:11:13,030 --> 00:11:04,800
a

321
00:11:15,910 --> 00:11:13,040
number of

322
00:11:16,310 --> 00:11:15,920
opaque pyrite framboids in each sample

323
00:11:19,030 --> 00:11:16,320
uh

324
00:11:21,110 --> 00:11:19,040
with the total organic total organic

325
00:11:23,350 --> 00:11:21,120
carbon content of each sample

326
00:11:24,630 --> 00:11:23,360
and we found a uh a significant

327
00:11:28,069 --> 00:11:24,640
relationship across

328
00:11:30,949 --> 00:11:28,079
uh seven or uh sorry uh 10 or 11 samples

329
00:11:31,269 --> 00:11:30,959
um that the more pyrite framboids we

330
00:11:34,389 --> 00:11:31,279
have

331
00:11:36,150 --> 00:11:34,399
generally the more organic carbon we did

332
00:11:37,509 --> 00:11:36,160
have this this outlier which i did

333
00:11:40,150 --> 00:11:37,519
choose to include

334
00:11:41,910 --> 00:11:40,160
because it was a sample with both the

335
00:11:42,310 --> 00:11:41,920
highest organic carbon content and the

336
00:11:47,190 --> 00:11:42,320
most

337
00:11:50,629 --> 00:11:47,200
framboids so this suggests that sulfur

338
00:11:52,870 --> 00:11:50,639

is in some way or shape or form

339
00:11:55,509 --> 00:11:52,880
related to the preservation of organic

340
00:11:58,629 --> 00:11:55,519
carbon in these soils

341
00:12:00,470 --> 00:11:58,639
so um that's what we're at right now uh

342
00:12:01,910 --> 00:12:00,480
this is for our preliminary and ongoing

343
00:12:03,030 --> 00:12:01,920
research so we can't draw any

344
00:12:06,230 --> 00:12:03,040
conclusions

345
00:12:07,110 --> 00:12:06,240
as to whether um these uh these ancient

346
00:12:09,350 --> 00:12:07,120
soils contain

347
00:12:11,509 --> 00:12:09,360
biogenic organic carbon because there

348
00:12:14,150 --> 00:12:11,519
are many ways that abiotic

349
00:12:14,949 --> 00:12:14,160
organic carbon can be formed we also

350
00:12:18,389 --> 00:12:14,959
need to know

351
00:12:20,710 --> 00:12:18,399
um you know like if there's any modern

352
00:12:22,310 --> 00:12:20,720
contamination which we haven't done yet

353
00:12:24,069 --> 00:12:22,320
and so radiocarbon dating of these

354
00:12:25,910 --> 00:12:24,079
samples would be a way to rule out any

355
00:12:26,710 --> 00:12:25,920
recent or modern contamination from

356
00:12:29,350 --> 00:12:26,720
stuff

357
00:12:31,030 --> 00:12:29,360
less than about fifty thousand years old

358
00:12:32,470 --> 00:12:31,040
so that's all i got um thank you guys