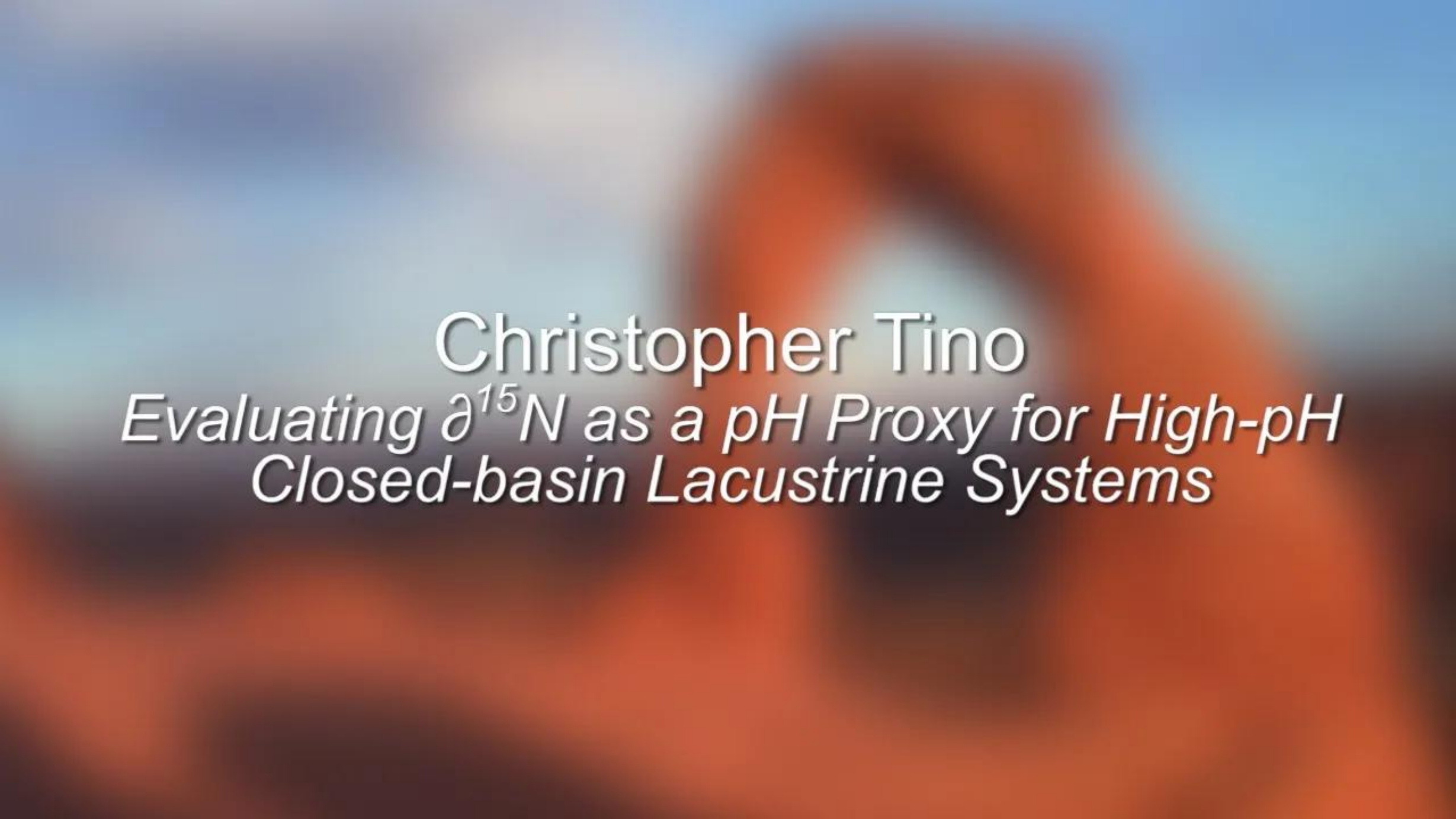

# Christopher Tino

## *Evaluating $\partial^{15}N$ as a pH Proxy for High-pH Closed-basin Lacustrine Systems*

1
00:00:00,240 --> 00:00:11,110
[Music]

2
00:00:14,690 --> 00:00:13,459
all right so quickly before I jump right

3
00:00:16,340 --> 00:00:14,700
in

4
00:00:17,690 --> 00:00:16,350
I recognize that some people might not

5
00:00:20,150 --> 00:00:17,700
be familiar with stable isotope

6
00:00:21,710 --> 00:00:20,160
chemistry so I'm supposed to say that

7
00:00:23,000 --> 00:00:21,720
this notation here is very important for

8
00:00:24,650 --> 00:00:23,010
this talk

9
00:00:26,270 --> 00:00:24,660
the key idea to understand here is that

10
00:00:27,860 --> 00:00:26,280
a very prominent subfield of

11
00:00:31,280 --> 00:00:27,870
geochemistry for the last 70 or 80 years

12
00:00:34,009 --> 00:00:31,290
or so has been involving creasing steel

13
00:00:36,950 --> 00:00:34,019

isotope ratios in common elemental

14
00:00:39,680 --> 00:00:36,960
systems so for instance nitrogen we have

15
00:00:41,720 --> 00:00:39,690
two major stable isotopes one which is

16
00:00:43,880 --> 00:00:41,730
just standard 14 nitrogen so that's just

17
00:00:45,229 --> 00:00:43,890
7 protons 7 neutrons the other that

18
00:00:48,020 --> 00:00:45,239
occurs in nature is significantly less

19
00:00:50,540 --> 00:00:48,030
abundant but it's 15 n so just add a

20
00:00:52,809 --> 00:00:50,550
neutron then you get to 15 n so you can

21
00:00:55,160 --> 00:00:52,819
trace the relative abundance ease of

22
00:00:56,689 --> 00:00:55,170
substance and see what their nitrogen

23
00:00:58,099 --> 00:00:56,699
content is like and you can track all

24
00:01:00,529 --> 00:00:58,109
sorts of interesting antibiotic and

25
00:01:04,670 --> 00:01:00,539
biological processes this way it's been

26
00:01:06,770 --> 00:01:04,680
a very successful field so I am super

27
00:01:09,560 --> 00:01:06,780
interested in certain Delta 15 in

28
00:01:12,770 --> 00:01:09,570
understanding a big thing to take away

29
00:01:15,440 --> 00:01:12,780
is that a positive value here means that

30
00:01:17,300 --> 00:01:15,450
it has more 15 n in it than the

31
00:01:20,360 --> 00:01:17,310
atmosphere does and if it's a negative

32
00:01:21,350 --> 00:01:20,370
value it means it is less I'm going to

33
00:01:22,430 --> 00:01:21,360
almost exclusively be talking about

34
00:01:25,130 --> 00:01:22,440
positive value that's what I'm really

35
00:01:26,570 --> 00:01:25,140
interested in Delta CN n has kind of a

36
00:01:29,240 --> 00:01:26,580
reputation as being a boring

37
00:01:31,010 --> 00:01:29,250
conservative isotope signature lots of

38
00:01:33,350 --> 00:01:31,020

stuff kind of crunch toward zero

39
00:01:35,510 --> 00:01:33,360
lots of microbial wash out and die

40
00:01:37,130 --> 00:01:35,520
genetic processing but actually I think

41
00:01:39,830 --> 00:01:37,140
that's wrong there are really exciting

42
00:01:41,150 --> 00:01:39,840
hugely positive values throughout the

43
00:01:43,280 --> 00:01:41,160
rock record and we'll be talking about

44
00:01:47,060 --> 00:01:43,290
maybe how we get there it's not really

45
00:01:48,560 --> 00:01:47,070
well understood so for instance this is

46
00:01:50,600 --> 00:01:48,570
a really good example of big nitrogen

47
00:01:52,220 --> 00:01:50,610
this is like the biggest nitrogen found

48
00:01:56,510 --> 00:01:52,230
in the rock records to my own formation

49
00:01:59,360 --> 00:01:56,520
about 2.7 to GigaOM billion years ago so

50
00:02:01,610 --> 00:01:59,370
well within the Archaean any values go

51
00:02:02,660 --> 00:02:01,620
well above 50 per mil which for anybody

52
00:02:05,900 --> 00:02:02,670
who studies the sorts of thing is

53
00:02:08,869 --> 00:02:05,910
incredibly extreme but a little more

54
00:02:10,819 --> 00:02:08,879
closer to home would be the Green River

55
00:02:12,500 --> 00:02:10,829
Formation here this these are actually

56
00:02:12,970 --> 00:02:12,510
samples that recently process from a

57
00:02:17,649 --> 00:02:12,980
drill

58
00:02:20,320 --> 00:02:17,659
from this room in the unit's a basin in

59
00:02:24,039 --> 00:02:20,330
Utah and as you can see as we progress

60
00:02:26,649 --> 00:02:24,049
through several Lake phases here we see

61
00:02:28,119 --> 00:02:26,659
this upward increase steadily but surely

62
00:02:32,589 --> 00:02:28,129
of these Nitra nights no compounds and

63
00:02:34,000 --> 00:02:32,599

we get well above 15 to 20 values so a

64
00:02:36,940 --> 00:02:34,010
good rule of thumb here is anything

65
00:02:38,740 --> 00:02:36,950
larger than 10 to 12 per mil on the

66
00:02:40,210 --> 00:02:38,750
Delta 59 scale especially in the rock

67
00:02:43,180 --> 00:02:40,220
record they're getting the rock record

68
00:02:48,039 --> 00:02:43,190
is really rare

69
00:02:49,360 --> 00:02:48,049
borderline anomalous and so my general

70
00:02:53,349 --> 00:02:49,370
motivations here it's kind of like

71
00:02:55,000 --> 00:02:53,359
sliding the PDF but generally my

72
00:02:57,460 --> 00:02:55,010
motivations are similar to what maria

73
00:02:59,589 --> 00:02:57,470
described really well which is that I'm

74
00:03:02,289 --> 00:02:59,599
really excited about March 2020 and the

75
00:03:03,670 --> 00:03:02,299
potential sample retrieval mission which

76
00:03:04,869 --> 00:03:03,680
this is the landing site so hopefully

77
00:03:05,949 --> 00:03:04,879
everybody should be familiar with this

78
00:03:08,199 --> 00:03:05,959
because it's supposed to be in the news

79
00:03:12,970 --> 00:03:08,209
a lot this is the chosen site Jezreel

80
00:03:15,309 --> 00:03:12,980
crater really exciting has carbonates it

81
00:03:17,229 --> 00:03:15,319
has filed silicate clays such as non

82
00:03:20,770 --> 00:03:17,239
tonight instability field of these clays

83
00:03:27,870 --> 00:03:20,780
kind of indicates that the pH was most

84
00:03:31,140 --> 00:03:27,880
likely circum neutral circum neutral 2

85
00:03:34,330 --> 00:03:31,150
to alkaline and that's a non-trivial

86
00:03:37,839 --> 00:03:34,340
thing right so alkaline environments are

87
00:03:40,120 --> 00:03:37,849
among the most bio productive if not the

88
00:03:42,879 --> 00:03:40,130

most productive natural aquatic systems

89
00:03:44,349 --> 00:03:42,889
that occur on earth and so determining

90
00:03:45,640 --> 00:03:44,359
that is really important to me and I'm

91
00:03:47,470 --> 00:03:45,650
really interested in the pH story that

92
00:03:50,199 --> 00:03:47,480
may be going on in general crater during

93
00:03:53,129 --> 00:03:50,209
its paleo Lake life time sometimes 3.5

94
00:03:55,990 --> 00:03:53,139
billion years ago or greater so

95
00:03:59,379 --> 00:03:56,000
naturally I go and I study crater lake

96
00:04:01,180 --> 00:03:59,389
sites now this is a town in Germany

97
00:04:02,470 --> 00:04:01,190
called nördlingen and locally at least

98
00:04:03,699 --> 00:04:02,480
its kind of famous for being the town

99
00:04:06,099 --> 00:04:03,709
built inside of a crater

100
00:04:09,670 --> 00:04:06,109
really cool right has a circular shape

101
00:04:12,099 --> 00:04:09,680
well unfortunately it's a the image was

102
00:04:14,140 --> 00:04:12,109
deceiving it's really town built inside

103
00:04:15,640 --> 00:04:14,150
of a much much larger crater this is

104
00:04:18,250 --> 00:04:15,650
just a fortified wall because this is an

105
00:04:20,229 --> 00:04:18,260
800 year old village before I win I

106
00:04:22,149 --> 00:04:20,239
really thought this was the crater it

107
00:04:23,650 --> 00:04:22,159
was built inside of the crater is much

108
00:04:25,330 --> 00:04:23,660
much larger

109
00:04:30,130 --> 00:04:25,340
it's about 25 kilometers in diameter

110
00:04:32,170 --> 00:04:30,140
structurally and so it's inner ring is

111
00:04:33,850 --> 00:04:32,180
about 12 to 13 kilometers that's this

112
00:04:36,610 --> 00:04:33,860
ring right here its outer ring is about

113
00:04:38,260 --> 00:04:36,620

25 kilometers and shortly after its

114
00:04:43,110 --> 00:04:38,270
formation in under an impact about four

115
00:04:45,460 --> 00:04:43,120
fourteen point eight billion years ago a

116
00:04:47,740 --> 00:04:45,470
lake formed in the crater for about five

117
00:04:50,710 --> 00:04:47,750
hundred million years - for about five

118
00:04:51,850 --> 00:04:50,720
hundred thousand years sorry yeah for

119
00:04:54,970 --> 00:04:51,860
about five hundred thousand years - two

120
00:04:56,680 --> 00:04:54,980
million years the depth of the sediments

121
00:04:57,670 --> 00:04:56,690
left over from that Lake or about five

122
00:04:59,680 --> 00:04:57,680
hundred meters deep

123
00:05:01,690 --> 00:04:59,690
the bretch Atlantis or like the true

124
00:05:03,160 --> 00:05:01,700
crater basement on which those sediments

125
00:05:05,980 --> 00:05:03,170
lie on top of about eight hundred meters

126
00:05:07,930 --> 00:05:05,990
deep when the impactor struck therefore

127
00:05:09,310 --> 00:05:07,940
it must have been about 1.2 to 1.5

128
00:05:10,990 --> 00:05:09,320
kilometers in diameter obviously it

129
00:05:13,090 --> 00:05:11,000
wasn't a perfectly spherical object but

130
00:05:16,210 --> 00:05:13,100
and velocity therefore must have been

131
00:05:17,500 --> 00:05:16,220
around 15 to 20 kilometers per second so

132
00:05:19,240 --> 00:05:17,510
something really interesting happened

133
00:05:21,100 --> 00:05:19,250
beyond just the intensity of the impact

134
00:05:23,200 --> 00:05:21,110
what is that what's left over now is

135
00:05:26,350 --> 00:05:23,210
this really well-preserved dual-layer

136
00:05:27,820 --> 00:05:26,360
ejecta blanket if this makes this a

137
00:05:28,870 --> 00:05:27,830
really fantastic Mars analog this is the

138
00:05:31,390 --> 00:05:28,880

only place on earth where this sort of

139
00:05:33,160 --> 00:05:31,400
dule your ejecta blanket is preserved

140
00:05:36,730 --> 00:05:33,170
it's quite sitting there in that regard

141
00:05:38,920 --> 00:05:36,740
and the reason it's really important

142
00:05:41,050 --> 00:05:38,930
really interesting is because it have a

143
00:05:43,000 --> 00:05:41,060
top layer called su vite here and a

144
00:05:44,230 --> 00:05:43,010
bottom layer called Punta beretta and

145
00:05:44,950 --> 00:05:44,240
the way to think about this is when the

146
00:05:47,590 --> 00:05:44,960
impact occurred

147
00:05:48,790 --> 00:05:47,600
it created a massively deep cavity much

148
00:05:50,350 --> 00:05:48,800
deeper than the bretch lens I was

149
00:05:51,550 --> 00:05:50,360
talking about before summer on the order

150
00:05:53,409 --> 00:05:51,560
of three or four kilometers deep

151
00:05:56,290 --> 00:05:53,419
immediately that only existed for

152
00:05:57,670 --> 00:05:56,300
seconds if that and then a bunch of

153
00:06:00,790 --> 00:05:57,680
sediment collapse right into the crater

154
00:06:02,530 --> 00:06:00,800
that was just newly formed and so all

155
00:06:03,640 --> 00:06:02,540
the materials immediately displaced by

156
00:06:05,110 --> 00:06:03,650
the impacts was the stuff that layed on

157
00:06:07,480 --> 00:06:05,120
top it was like Jurassic and Triassic

158
00:06:08,860 --> 00:06:07,490
limestone you know old Marine base rocks

159
00:06:11,200 --> 00:06:08,870
that were just underneath the soil and

160
00:06:13,510 --> 00:06:11,210
those form this boom tube retro bottom

161
00:06:15,610 --> 00:06:13,520
layer sort of just a breccia dwell

162
00:06:18,760 --> 00:06:15,620
mashed-up was really it's the Fenster

163
00:06:21,250 --> 00:06:18,770

for mashed up rock like the limestone on

164
00:06:23,170 --> 00:06:21,260
top and then when all the material

165
00:06:25,240 --> 00:06:23,180
collapse was highly pressurized basement

166
00:06:26,590 --> 00:06:25,250
rock that was really crystalline they

167
00:06:28,090 --> 00:06:26,600
basically formed a pressure cooker

168
00:06:30,100 --> 00:06:28,100
environment for a short period of time

169
00:06:30,629 --> 00:06:30,110
and then a secondary plume exploded out

170
00:06:33,450 --> 00:06:30,639
of the

171
00:06:35,369 --> 00:06:33,460
in that site and thinly settled over

172
00:06:37,140 --> 00:06:35,379
this bottom layer depression that's what

173
00:06:39,899 --> 00:06:37,150
this top layer is sumak so actually this

174
00:06:41,700 --> 00:06:39,909
form first this form second but the

175
00:06:42,929 --> 00:06:41,710
reality of the situation is that this is

176
00:06:45,570 --> 00:06:42,939
what it looks like in person it's

177
00:06:48,689 --> 00:06:45,580
exquisitely well-preserved we have the

178
00:06:52,200 --> 00:06:48,699
sous-vide layer here grayish material

179
00:06:56,730 --> 00:06:52,210
and we have this brown reddish material

180
00:06:59,249 --> 00:06:56,740
called breccia leaving hypotheses so

181
00:07:00,480 --> 00:06:59,259
this is that two bytes

182
00:07:02,730 --> 00:07:00,490
that's too bit later that I was talking

183
00:07:04,320 --> 00:07:02,740
about draw is thanks for like a volcanic

184
00:07:06,839 --> 00:07:04,330
glass when it interacts with water so

185
00:07:08,850 --> 00:07:06,849
it's gonna be stripping any water that's

186
00:07:10,110 --> 00:07:08,860
of its protons it's going to be driving

187
00:07:11,969 --> 00:07:10,120
alkalinity it's going to be increasing

188
00:07:14,610 --> 00:07:11,979

the pH and then after all that's been

189
00:07:16,320 --> 00:07:14,620
weather and wrote it will be left over

190
00:07:17,309 --> 00:07:16,330
whether to be Boone's pressure was and

191
00:07:18,899 --> 00:07:17,319
that's going to weather and that's

192
00:07:20,550 --> 00:07:18,909
essentially going to weather like a like

193
00:07:22,559 --> 00:07:20,560
an oceanic rock night increasing

194
00:07:25,200 --> 00:07:22,569
salinity returning the pH back towards

195
00:07:26,820 --> 00:07:25,210
eight or so and so it has this really

196
00:07:33,769 --> 00:07:26,830
interesting history of multiple lake

197
00:07:40,740 --> 00:07:36,240
there we go a lot of stick around here

198
00:07:43,170 --> 00:07:40,750
unless I can't um so yeah first thing

199
00:07:44,209 --> 00:07:43,180
about this weathering into the catchment

200
00:07:46,499 --> 00:07:44,219
area of the crater

201
00:07:48,629 --> 00:07:46,509
Creighton's really upland high pH water

202
00:07:50,279 --> 00:07:48,639
and then once this all goes away we're

203
00:07:53,010 --> 00:07:50,289
starting to whether this material and it

204
00:07:58,230 --> 00:07:53,020
rapidly changes the nature of the lake

205
00:08:00,930 --> 00:07:58,240
itself and so in order to explore what

206
00:08:02,129 --> 00:08:00,940
this really meant i am i example drill

207
00:08:04,740 --> 00:08:02,139
core that's what we do is do you account

208
00:08:06,869 --> 00:08:04,750
us so there was a joke or here within

209
00:08:09,149 --> 00:08:06,879
this crater basin that was drilled in

210
00:08:12,689 --> 00:08:09,159
1973 this really awesome academic core

211
00:08:15,269 --> 00:08:12,699
and here's what we got out of in terms

212
00:08:16,230 --> 00:08:15,279
of delta 15n all those PS changes put in

213
00:08:18,570 --> 00:08:16,240

our mind that there might be a really

214
00:08:19,680 --> 00:08:18,580
interesting story here and when this

215
00:08:20,999 --> 00:08:19,690
these data came through we were really

216
00:08:23,309 --> 00:08:21,009
excited this was definitely like a

217
00:08:24,839 --> 00:08:23,319
straight up high five next to this mass

218
00:08:28,110 --> 00:08:24,849
spectrometer moment when we saw this

219
00:08:30,089 --> 00:08:28,120
spike down here and so when i mean we I

220
00:08:31,980 --> 00:08:30,099
mean myself and Eva stoic and who's a

221
00:08:33,719 --> 00:08:31,990
world-class matron expert that I have

222
00:08:37,319 --> 00:08:33,729
had the good fortune of working with the

223
00:08:39,899 --> 00:08:37,329
University of st. Andrews and right here

224
00:08:41,939 --> 00:08:39,909
we see this minimum value of 3.2 per mil

225
00:08:42,920 --> 00:08:41,949
and a maximum value of 17 point four

226
00:08:44,930 --> 00:08:42,930
seven from

227
00:08:46,550 --> 00:08:44,940
and the really interesting thing about

228
00:08:48,290 --> 00:08:46,560
this is these occur over this tiny

229
00:08:50,000 --> 00:08:48,300
interval that's the 3.8 two values

230
00:08:52,370 --> 00:08:50,010
that's the seventeen point four seven

231
00:08:53,810 --> 00:08:52,380
per mil value and although we don't have

232
00:08:55,760 --> 00:08:53,820
great time resolution looks like because

233
00:08:58,550 --> 00:08:55,770
there's such an extreme chemistry that

234
00:09:00,590 --> 00:08:58,560
is a that is a very short interval of

235
00:09:02,150 --> 00:09:00,600
course pace to make that sort of jump in

236
00:09:04,910 --> 00:09:02,160
chemistry and we see this really

237
00:09:06,890 --> 00:09:04,920
interesting secular trend that slowly

238
00:09:08,060 --> 00:09:06,900

degrade decreases and it really seems to

239
00:09:10,310 --> 00:09:08,070
match up well with what's involved

240
00:09:13,460 --> 00:09:10,320
previously for pH by by our sort of

241
00:09:15,079 --> 00:09:13,470
Resident collaborator and local rescreen

242
00:09:19,160 --> 00:09:15,089
or expert Brent on our course at the

243
00:09:21,410 --> 00:09:19,170
university of girding and so the

244
00:09:24,079 --> 00:09:21,420
mechanism or revoking for understands pH

245
00:09:28,310 --> 00:09:24,089
Delta 15 and relationship is ammonia

246
00:09:30,769 --> 00:09:28,320
volatilization so ammonia ammonium and

247
00:09:33,980 --> 00:09:30,779
ammonia have you know a PKA relationship

248
00:09:35,030 --> 00:09:33,990
that subtle scent 9.25 which for those

249
00:09:35,720 --> 00:09:35,040
of you know haven't thought about this

250
00:09:37,610 --> 00:09:35,730
in quite some time

251
00:09:40,190 --> 00:09:37,620
that means at pH and I points you five

252
00:09:42,710 --> 00:09:40,200
at STP they're going to be in equal

253
00:09:43,700 --> 00:09:42,720
parts in solution right at a pH are

254
00:09:46,070 --> 00:09:43,710
around seven is gonna be almost

255
00:09:47,900 --> 00:09:46,080
exclusively ammonium and then a pH

256
00:09:54,650 --> 00:09:47,910
operator runs well it's going to be

257
00:09:56,000 --> 00:09:54,660
exclusively ammonia so understanding

258
00:09:58,910 --> 00:09:56,010
this we can say okay has the pH

259
00:09:59,960 --> 00:09:58,920
increases towards the 9.25 or even a

260
00:10:02,900 --> 00:09:59,970
little bit below that you're gonna start

261
00:10:04,190 --> 00:10:02,910
generating more and more ammonia now

262
00:10:06,350 --> 00:10:04,200
they don't really settle nicely in

263
00:10:08,690 --> 00:10:06,360

solution because ammonia in most cases

264
00:10:10,160 --> 00:10:08,700
on this planet becomes gas maybe a

265
00:10:12,019 --> 00:10:10,170
unidirectional escape of that ammonia

266
00:10:14,930 --> 00:10:12,029
from the from the Basin from the front

267
00:10:16,670 --> 00:10:14,940
of the lake itself so that's what we

268
00:10:18,590 --> 00:10:16,680
predict is happening here as we as we

269
00:10:19,790 --> 00:10:18,600
increase alkalinity rapidly essentially

270
00:10:21,890 --> 00:10:19,800
what's going to happen is this is like a

271
00:10:23,480 --> 00:10:21,900
freshwater playa that's just forming on

272
00:10:26,720 --> 00:10:23,490
top of these really strange rocks in the

273
00:10:27,860 --> 00:10:26,730
in the crater in a crater basin and as

274
00:10:29,840 --> 00:10:27,870
soon as there's enough weathering going

275
00:10:32,750 --> 00:10:29,850
on you see this big jump in alkalinity

276
00:10:37,190 --> 00:10:32,760
and it's going sided with these losses

277
00:10:38,780 --> 00:10:37,200
big jump in values so take-home point

278
00:10:40,519 --> 00:10:38,790
the heads are talking like gaseous

279
00:10:42,590 --> 00:10:40,529
ammonia escapes and leaves ice table

280
00:10:44,810 --> 00:10:42,600
heavy ammonia isotopic Li heavy ammonium

281
00:10:46,400 --> 00:10:44,820
pool behind right so the lighter stuff

282
00:10:47,900 --> 00:10:46,410
is getting more preferentially is the

283
00:10:50,639 --> 00:10:47,910
term we would just preferentially leave

284
00:10:54,460 --> 00:10:52,749
now we have some additional evidence for

285
00:10:56,470 --> 00:10:54,470
this high pH interval is sort of bolster

286
00:10:58,239 --> 00:10:56,480
this argument we have an abundance of

287
00:10:59,970 --> 00:10:58,249
zeolites these are minerals such as an

288
00:11:02,679 --> 00:10:59,980

assignemnt clean off light

289
00:11:04,900 --> 00:11:02,689
geologically they're indicative of high

290
00:11:06,759 --> 00:11:04,910
pH environments we also have a paucity

291
00:11:08,980 --> 00:11:06,769
of micro fossils so if we look here we

292
00:11:11,919 --> 00:11:08,990
can see there fish in our ostracods

293
00:11:15,129 --> 00:11:11,929
essentially disappear this becomes some

294
00:11:16,749 --> 00:11:15,139
sort of high pH super brackish

295
00:11:18,340 --> 00:11:16,759
potentially eutrophic scenario or there

296
00:11:20,230 --> 00:11:18,350
isn't really enough oxygen maybe you

297
00:11:21,780 --> 00:11:20,240
blow that top layer for a lot of these

298
00:11:23,889 --> 00:11:21,790
macro fossils to live in anymore

299
00:11:25,419 --> 00:11:23,899
and then we have a general scarcity of

300
00:11:26,919 --> 00:11:25,429
diatoms so diatoms play a little bit

301
00:11:29,049 --> 00:11:26,929
better with high pH environments but

302
00:11:31,419 --> 00:11:29,059
probably not quite as high as it got its

303
00:11:33,369 --> 00:11:31,429
greatest point probably around nine

304
00:11:35,019 --> 00:11:33,379
point two five to nine point five pH so

305
00:11:36,669 --> 00:11:35,029
the diatoms tended to also not leave

306
00:11:37,989 --> 00:11:36,679
fossils at this point and slowly kind of

307
00:11:42,129 --> 00:11:37,999
reintegrated themselves back in the lake

308
00:11:43,540 --> 00:11:42,139
has pH decreased we also can combine

309
00:11:45,309 --> 00:11:43,550
this with some previous isotope data it

310
00:11:48,609 --> 00:11:45,319
was really useful this is from an old

311
00:11:50,319 --> 00:11:48,619
paper by Rothen house from 1977 they

312
00:11:53,470 --> 00:11:50,329
measured the Delta o-18 of the carbon a

313
00:11:55,929 --> 00:11:53,480

delta 13c of the carbonate in the same

314
00:11:58,539 --> 00:11:55,939
drill core and this has actually been

315
00:12:01,030 --> 00:11:58,549
used these data has a classic example of

316
00:12:04,410 --> 00:12:01,040
closed basin behavior so for anybody who

317
00:12:07,720 --> 00:12:04,420
studies lakes ur hasn't even dabbled

318
00:12:10,150 --> 00:12:07,730
this Talbott cetacean here from 1990 is

319
00:12:13,720 --> 00:12:10,160
like a classic Paleo lacrosse tree and

320
00:12:15,309 --> 00:12:13,730
chemistry cetacean and they use Reece

321
00:12:17,169 --> 00:12:15,319
crater as an example of tight Co

322
00:12:19,269 --> 00:12:17,179
variation between Delta 13 C and up to

323
00:12:21,009 --> 00:12:19,279
18 carbonates and how it relates is a

324
00:12:22,509 --> 00:12:21,019
closed basin behavior so this was a

325
00:12:27,009 --> 00:12:22,519
pretty restrictive for the most part in

326
00:12:28,150 --> 00:12:27,019
its lifetime and the other thing we can

327
00:12:29,650 --> 00:12:28,160
glean from this is that there's probably

328
00:12:30,970 --> 00:12:29,660
a progressive includes an increase in

329
00:12:33,009 --> 00:12:30,980
salinity because what this closed basin

330
00:12:35,079 --> 00:12:33,019
relationship also comes you know a

331
00:12:36,660 --> 00:12:35,089
strong dependency on the fact the

332
00:12:39,699 --> 00:12:36,670
effects like evaporation and evaporation

333
00:12:41,109 --> 00:12:39,709
as a result so progressive increase in

334
00:12:42,489 --> 00:12:41,119
salinity during this interval as well so

335
00:12:45,759 --> 00:12:42,499
simplified picture of this would kind of

336
00:12:48,730 --> 00:12:45,769
be this yellowish region here Evelyn

337
00:12:50,259 --> 00:12:48,740
this gray line here you can think of it

338
00:12:52,119 --> 00:12:50,269

as probably being redox stratified and

339
00:12:53,799 --> 00:12:52,129
then increases in salinity and it

340
00:12:55,299 --> 00:12:53,809
probably almost exclusively continues

341
00:12:58,720 --> 00:12:55,309
increase in the salinity of the through

342
00:13:02,800 --> 00:13:00,910
there is some relevant literature all

343
00:13:04,960 --> 00:13:02,810
right there was some literature already

344
00:13:08,080 --> 00:13:04,970
published in illness in terms of the

345
00:13:10,210 --> 00:13:08,090
ammonium ammonia Delta 59 relationship

346
00:13:12,430 --> 00:13:10,220
we had some theoretical understanding

347
00:13:14,980 --> 00:13:12,440
from the most classic stable isotope

348
00:13:17,800 --> 00:13:14,990
favored by Yuri in 1947 and what she

349
00:13:20,410 --> 00:13:17,810
said okay we just calculate ab initio

350
00:13:21,070 --> 00:13:20,420
the values of ammonium and ammonia in

351
00:13:23,290 --> 00:13:21,080
this relationship

352
00:13:24,550 --> 00:13:23,300
then when dissociates it should be in a

353
00:13:26,170 --> 00:13:24,560
fractionation or about thirty eight

354
00:13:28,420 --> 00:13:26,180
point two five at zero degrees or thirty

355
00:13:29,890 --> 00:13:28,430
four point four and twenty five degrees

356
00:13:32,230 --> 00:13:29,900
we also have some more recent

357
00:13:33,610 --> 00:13:32,240
experimental work done lately at all and

358
00:13:35,440 --> 00:13:33,620
egg and all that shows fractionation up

359
00:13:37,690 --> 00:13:35,450
to forty five point four per mil at 23

360
00:13:39,160 --> 00:13:37,700
degrees when you're basically setting up

361
00:13:41,170 --> 00:13:39,170
the scenario to fraction eight as much

362
00:13:42,550 --> 00:13:41,180
as possible your your bubbling h2

363
00:13:44,680 --> 00:13:42,560

underneath that you're heating it up it

364
00:13:46,120 --> 00:13:44,690
is stepwise and you're seeing how much

365
00:13:50,050 --> 00:13:46,130
can possibly fraction a in an ideal

366
00:13:51,220 --> 00:13:50,060
situation so long story short the

367
00:13:52,570 --> 00:13:51,230
reaction behavior is sort of this

368
00:13:54,730 --> 00:13:52,580
kinetic reaction the mix with

369
00:13:56,560 --> 00:13:54,740
equilibrium reaction right because it is

370
00:13:57,820 --> 00:13:56,570
an equilibrium reaction initially but

371
00:14:00,220 --> 00:13:57,830
then it has a unidirectional escape

372
00:14:03,730 --> 00:14:00,230
which which gives it a kinetic a sort of

373
00:14:06,010 --> 00:14:03,740
kinetic effect but now theoretical

374
00:14:07,200 --> 00:14:06,020
experimental what's needed now is this

375
00:14:10,480 --> 00:14:07,210
fieldwork right that's the next

376
00:14:12,130 --> 00:14:10,490
progression so I went out to ku wrong

377
00:14:16,600 --> 00:14:12,140
National Park in South Australia's last

378
00:14:20,280 --> 00:14:16,610
summer it's a sample what's known to be

379
00:14:22,690 --> 00:14:20,290
a very interesting gradient of high pH

380
00:14:23,890 --> 00:14:22,700
Minnie Lake systems basically that we

381
00:14:25,720 --> 00:14:23,900
thought would be a really nice gradient

382
00:14:27,400 --> 00:14:25,730
to sample and see we're in this effect

383
00:14:29,050 --> 00:14:27,410
takes place and whether or not you have

384
00:14:32,340 --> 00:14:29,060
this kind of increase has moved from

385
00:14:34,930 --> 00:14:32,350
Lake that is typically around 7.75 pH

386
00:14:38,710 --> 00:14:34,940
28.8 pH all the way up to nine point

387
00:14:41,590 --> 00:14:38,720
five or so so this is the region of

388
00:14:43,240 --> 00:14:41,600

study particularly we were focused in

389
00:14:45,450 --> 00:14:43,250
the Salt Creek region so here's what was

390
00:14:47,710 --> 00:14:45,460
referred to as the KU wrong it's this

391
00:14:50,410 --> 00:14:47,720
could be reverting is like an inverse

392
00:14:54,250 --> 00:14:50,420
estuary it takes water from the ocean

393
00:14:56,440 --> 00:14:54,260
and actually makes it saltier and then

394
00:14:58,420 --> 00:14:56,450
if we could hear that was more focused

395
00:15:01,300 --> 00:14:58,430
in the Salt Creek region which is also

396
00:15:04,390 --> 00:15:01,310
pictured here clarity zoom in a little

397
00:15:06,280 --> 00:15:04,400
bit so example three sites in the Salt

398
00:15:10,030 --> 00:15:06,290
Creek region Haley Lake dolomite lake in

399
00:15:12,180 --> 00:15:10,040
North stromatolite Lake and as you know

400
00:15:16,020 --> 00:15:12,190
we also got a fourth sample down

401
00:15:18,120 --> 00:15:16,030
their self and a fit sample also further

402
00:15:19,440 --> 00:15:18,130
south and then a six sample that serve

403
00:15:24,900 --> 00:15:19,450
does kind of an M member and negative

404
00:15:26,940 --> 00:15:24,910
control from just the Marine setting so

405
00:15:30,270 --> 00:15:26,950
looking at that sedimentary Delta 15 nd

406
00:15:31,620 --> 00:15:30,280
the marine and remember acted it hasn't

407
00:15:33,450 --> 00:15:31,630
even expect so it was a good negative

408
00:15:35,280 --> 00:15:33,460
control generally speaking if you go out

409
00:15:37,410 --> 00:15:35,290
to a marine system and you measure the

410
00:15:39,450 --> 00:15:37,420
Delta 15 n of the sediments you will

411
00:15:41,460 --> 00:15:39,460
find around seven per mil plus or minus

412
00:15:42,690 --> 00:15:41,470
1.5 so we were happy with those data

413
00:15:44,670 --> 00:15:42,700

shown us over here someone on the right

414
00:15:46,560 --> 00:15:44,680
track here that we didn't have any flaws

415
00:15:50,310 --> 00:15:46,570
necessarily you know in our sampling

416
00:15:52,260 --> 00:15:50,320
strategy and then when we looked at all

417
00:15:54,920 --> 00:15:52,270
the other links we got this crazy spread

418
00:15:57,870 --> 00:15:54,930
so keep in mind that visually at least

419
00:16:00,420 --> 00:15:57,880
first order basis all these lakes looks

420
00:16:01,830 --> 00:16:00,430
very similar seem very similar to be

421
00:16:03,630 --> 00:16:01,840
there a lot of them has from analyst

422
00:16:05,250 --> 00:16:03,640
former in the ground there was active

423
00:16:07,740 --> 00:16:05,260
dolomite precipitation which is actually

424
00:16:10,710 --> 00:16:07,750
a really interesting the geochemical

425
00:16:12,270 --> 00:16:10,720
phenomena and the oil within 25 clock

426
00:16:14,130 --> 00:16:12,280
square kilometers of each other so this

427
00:16:17,550 --> 00:16:14,140
sort of variation in any isotope system

428
00:16:18,480 --> 00:16:17,560
is kind of bizarre we did see some of

429
00:16:20,030 --> 00:16:18,490
the behavior that we I guess

430
00:16:22,290 --> 00:16:20,040
hypothesized to be occurring in

431
00:16:23,520 --> 00:16:22,300
inhalants lake as we progressed down

432
00:16:24,930 --> 00:16:23,530
there sedimentary cores these are

433
00:16:26,160 --> 00:16:24,940
shorter cords right so the sediments are

434
00:16:28,170 --> 00:16:26,170
in depth we just pushed them into the

435
00:16:32,010 --> 00:16:28,180
ground remove them and extract and

436
00:16:33,570 --> 00:16:32,020
extruded the course inhale at Lake we

437
00:16:35,310 --> 00:16:33,580
can see that it has these really high

438
00:16:37,350 --> 00:16:35,320

value somewhere all the way up to 20 per

439
00:16:40,470 --> 00:16:37,360
mil like we were possibly expecting we

440
00:16:42,180 --> 00:16:40,480
can also see the dolomite lake having

441
00:16:44,160 --> 00:16:42,190
similar behavior mini dolomite lake at

442
00:16:45,510 --> 00:16:44,170
certain points in the year can act that

443
00:16:48,180 --> 00:16:45,520
way but then we also see these that have

444
00:16:49,980 --> 00:16:48,190
more normal soil profiles they kind of

445
00:16:51,270 --> 00:16:49,990
return back towards zero how's it going

446
00:16:56,420 --> 00:16:51,280
down with depth which is what you see in

447
00:17:02,570 --> 00:17:00,470
so our working hypothesis now is is that

448
00:17:03,950 --> 00:17:02,580
there has to be another factor affecting

449
00:17:08,540 --> 00:17:03,960
ammonia vult cessation that we didn't

450
00:17:10,490 --> 00:17:08,550
take into consideration and based on the

451
00:17:11,870 --> 00:17:10,500
evidence we do have right now the

452
00:17:13,250 --> 00:17:11,880
hypothesis that there was very high

453
00:17:15,680 --> 00:17:13,260
salinity at one point that high shalini

454
00:17:17,990 --> 00:17:15,690
may have significant effects on the

455
00:17:18,800 --> 00:17:18,000
nitrification so this idea is that you

456
00:17:22,100 --> 00:17:18,810
ever the high salinity

457
00:17:23,420 --> 00:17:22,110
you cannot take your ammonium and

458
00:17:25,280 --> 00:17:23,430
converted to ammonia and the biological

459
00:17:28,280 --> 00:17:25,290
cycle and therefore you have ammonium

460
00:17:30,350 --> 00:17:28,290
sitting around longer to act as this

461
00:17:32,720 --> 00:17:30,360
chemistry pool that will be really

462
00:17:34,820 --> 00:17:32,730
affected by pH changes and that will be

463
00:17:36,680 --> 00:17:34,830

shown in Delta 59 so this is just

464
00:17:39,080 --> 00:17:36,690
classic microbiology paper where you see

465
00:17:40,940 --> 00:17:39,090
an egg nitrosomonas species of

466
00:17:42,380 --> 00:17:40,950
freshwater isolate you know not playing

467
00:17:43,760 --> 00:17:42,390
well with high percentages of salinity

468
00:17:45,710 --> 00:17:43,770
from reference the ocean has the

469
00:17:48,170 --> 00:17:45,720
salinity of about 3.5 percent or 35

470
00:17:50,780 --> 00:17:48,180
practical salinity units there's a nest

471
00:17:52,250 --> 00:17:50,790
ruin sample that is acting similar

472
00:17:54,530 --> 00:17:52,260
acting so when you played a little bit

473
00:17:55,490 --> 00:17:54,540
better with slanty but still not very

474
00:17:59,360 --> 00:17:55,500
well you want to get to the three

475
00:18:02,300 --> 00:17:59,370
percent area and here are some data from

476
00:18:05,450 --> 00:18:02,310
the Quran Lagoon where the salinity we

477
00:18:08,740 --> 00:18:05,460
can see is actually about 15% so it's

478
00:18:10,910 --> 00:18:08,750
way more at least five times as much as

479
00:18:12,620 --> 00:18:10,920
the ocean in some cases during the

480
00:18:14,270 --> 00:18:12,630
summer it's only getting worse

481
00:18:18,650 --> 00:18:14,280
can't see it here but these days were

482
00:18:22,610 --> 00:18:18,660
really from from the knots so they ain't

483
00:18:23,690 --> 00:18:22,620
around 2008 and this is because there's

484
00:18:25,700 --> 00:18:23,700
been really poor water management

485
00:18:27,380 --> 00:18:25,710
patches here the dams that were built in

486
00:18:28,760 --> 00:18:27,390
early 20th century only to spiral this

487
00:18:30,110 --> 00:18:28,770
problem or somewhere somewhere so

488
00:18:31,370 --> 00:18:30,120

they're really hyper sea I mean and you

489
00:18:33,050 --> 00:18:31,380
can imagine there's varying degrees of

490
00:18:34,880 --> 00:18:33,060
interaction with these lake systems with

491
00:18:38,060 --> 00:18:34,890
this extremely hyper saline Lagoon here

492
00:18:40,550 --> 00:18:38,070
and so we think that there may be well

493
00:18:41,690 --> 00:18:40,560
now I look back and never look back at

494
00:18:43,730 --> 00:18:41,700
the Green River Formation data and I'm

495
00:18:45,290 --> 00:18:43,740
trying to wonder whether or not this

496
00:18:47,180 --> 00:18:45,300
jump from here to here has more to do

497
00:18:48,950 --> 00:18:47,190
with Lindy and does the pH is their

498
00:18:50,990 --> 00:18:48,960
salinity threshold we have to hit and

499
00:18:52,820 --> 00:18:51,000
then p2 effects start to be important

500
00:18:54,170 --> 00:18:52,830
these are questions now that I need to

501
00:18:55,880 --> 00:18:54,180
consider much more than I thought before

502
00:18:58,070 --> 00:18:55,890
before we generated these pilot data

503
00:18:59,390 --> 00:18:58,080
from from the Quran sediments and when

504
00:19:00,950 --> 00:18:59,400
it comes to jezero crater what this

505
00:19:02,960 --> 00:19:00,960
could mean for that you could mean that

506
00:19:04,850 --> 00:19:02,970
if we do find these sorts of anomalous

507
00:19:07,350 --> 00:19:04,860
Delta 15n values and the sediments in

508
00:19:09,330 --> 00:19:07,360
the samples that are returned

509
00:19:11,070 --> 00:19:09,340
that not only is it highly alkaline but

510
00:19:12,330 --> 00:19:11,080
it also is highly saline so even though

511
00:19:13,860 --> 00:19:12,340
we might not be able to get an exact pH

512
00:19:15,870 --> 00:19:13,870
relationship it could tell us two

513
00:19:17,370 --> 00:19:15,880

parameters and I personally would be

514
00:19:18,419 --> 00:19:17,380
really cool because you know it

515
00:19:20,190 --> 00:19:18,429
depresses the freezing point of the

516
00:19:22,200 --> 00:19:20,200
water which could explain how how Mars

517
00:19:24,120 --> 00:19:22,210
would have had some liquid water even

518
00:19:26,160 --> 00:19:24,130
during a faint young Sun period over 3.5

519
00:19:28,289 --> 00:19:26,170
billion years ago all right so I'll

520
00:19:29,880 --> 00:19:28,299
leave my conclusions up and well quickly

521
00:19:32,039 --> 00:19:29,890
acknowledgments Avis token University of

522
00:19:34,530 --> 00:19:32,049
st. Andrews mitogen Lyons girl harp

523
00:19:35,610 --> 00:19:34,540
music turning and Dan Gregory dan

524
00:19:36,900 --> 00:19:35,620
Gregory from Toronto who was

525
00:19:45,030 --> 00:19:36,910
instrumental to helping me do the

526
00:19:52,890 --> 00:19:45,040
sampling in Australia all right

527
00:19:54,780 --> 00:19:52,900
questions for Chris hey hey thank you

528
00:19:57,210 --> 00:19:54,790
for the talk I'm just curious with the

529
00:19:59,340 --> 00:19:57,220
Mars rovers like are they able are they

530
00:20:01,289 --> 00:19:59,350
gonna core like how deep will I go cuz

531
00:20:07,070 --> 00:20:01,299
this kind of comes from the Germany

532
00:20:10,320 --> 00:20:07,080
crater that was very good question so

533
00:20:11,700 --> 00:20:10,330
the markzware 20 rover is going to be

534
00:20:14,039 --> 00:20:11,710
equipped with basically the cigar sized

535
00:20:15,090 --> 00:20:14,049
tubes they're gonna be just tiny small

536
00:20:16,380 --> 00:20:15,100
of course they would be pressurized

537
00:20:18,060 --> 00:20:16,390
right into the sample and then cached

538
00:20:20,880 --> 00:20:18,070

either in a system or left behind for

539
00:20:22,860 --> 00:20:20,890
something else to pick it up later but

540
00:20:23,909 --> 00:20:22,870
the idea is within a crater lake system

541
00:20:25,530 --> 00:20:23,919
similar with her been doing with

542
00:20:27,750 --> 00:20:25,540
curiosity at Gale Crater is that you can

543
00:20:29,100 --> 00:20:27,760
get a transect so you can be working

544
00:20:30,030 --> 00:20:29,110
from different areas in the crater and

545
00:20:32,490 --> 00:20:30,040
if you're smart about how you're

546
00:20:34,650 --> 00:20:32,500
sampling you can really work upward

547
00:20:35,820 --> 00:20:34,660
through the history of the lake right so

548
00:20:36,960 --> 00:20:35,830
you don't need a core that goes into the

549
00:20:38,039 --> 00:20:36,970
ground so much as you can you kind of

550
00:20:39,570 --> 00:20:38,049
work upward through the history of the

551
00:20:41,250 --> 00:20:39,580
lake and be clever about what you're

552
00:20:42,840 --> 00:20:41,260
sampling and Tracy serves a similar

553
00:20:44,010 --> 00:20:42,850
relationship so if there was this dual

554
00:20:45,840 --> 00:20:44,020
layer objective pattern and it went

555
00:20:47,549 --> 00:20:45,850
through a similar chemical history to

556
00:20:49,200 --> 00:20:47,559
what we see at least greater then if

557
00:20:51,330 --> 00:20:49,210
we're clever enough about how we sample

558
00:20:54,260 --> 00:20:51,340
or how they sample I don't know who

559
00:20:56,730 --> 00:20:54,270
evolved but then then we could

560
00:20:59,760 --> 00:20:56,740
theoretically parse apart the history of

561
00:21:01,340 --> 00:20:59,770
the lake all right great let's think