
AbSciCon
2019

1
00:00:00,790 --> 00:00:07,320
[Music]

2
00:00:11,890 --> 00:00:09,240
[Applause]

3
00:00:14,740 --> 00:00:11,900
great thank you so quiet where this is

4
00:00:16,150 --> 00:00:14,750
due this is talk of the work by Chad

5
00:00:18,040 --> 00:00:16,160
Austria who's a graduate student working

6
00:00:19,570 --> 00:00:18,050
with me he couldn't be here for family

7
00:00:22,720 --> 00:00:19,580
reasons so he asked me to cover his talk

8
00:00:25,390 --> 00:00:22,730
and it's work that he began and has

9
00:00:26,650 --> 00:00:25,400
continued with SUNY Nielsen at Woods

10
00:00:28,450 --> 00:00:26,660
Hole Oceanographic Institution and

11
00:00:31,029 --> 00:00:28,460
Jeremy Owens when he was there as well

12
00:00:31,900 --> 00:00:31,039
as with my group so the stallion work

13
00:00:35,290 --> 00:00:31,910

I'm going to show you here tell him

14
00:00:37,300 --> 00:00:35,300
isotopes is pleadin generated at hui and

15
00:00:39,910 --> 00:00:37,310
this work follows on it's a it's a

16
00:00:42,100 --> 00:00:39,920
sequel of sequels to the whiff of oxygen

17
00:00:44,280 --> 00:00:42,110
story that began with his paper in 2007

18
00:00:47,200 --> 00:00:44,290
on a companion paper led by jake hoffman

19
00:00:51,100 --> 00:00:47,210
that argued based on molybdenum

20
00:00:53,650 --> 00:00:51,110
enrichments in 2.5 billion year old

21
00:00:57,100 --> 00:00:53,660
black shales the Mount Moriah shale that

22
00:00:58,720 --> 00:00:57,110
there was that this middle of an

23
00:00:59,980 --> 00:00:58,730
enrichment SAR evidence of trace oxygen

24
00:01:01,810 --> 00:00:59,990
in the in the environment at that time

25
00:01:03,130 --> 00:01:01,820
and subsequent to this paper has been a

26
00:01:04,570 --> 00:01:03,140
number of other studies a number other

27
00:01:05,950 --> 00:01:04,580
proxies it all kind of point in the same

28
00:01:08,289 --> 00:01:05,960
direction where the most parsimonious

29
00:01:09,910 --> 00:01:08,299
explanation is a whiff of oxygen small

30
00:01:12,820 --> 00:01:09,920
amounts of oxygen in the pre great

31
00:01:14,530 --> 00:01:12,830
oxidation event the pre goe environment

32
00:01:16,870 --> 00:01:14,540
and other studies have extended this

33
00:01:19,360 --> 00:01:16,880
kind of thinking back substantially

34
00:01:23,740 --> 00:01:19,370
earlier than you know and extra half

35
00:01:27,130 --> 00:01:23,750
billion years or more so so all of that

36
00:01:29,440 --> 00:01:27,140
work has has kind of solidified this

37
00:01:31,210 --> 00:01:29,450
notion that the pre goe environment was

38
00:01:33,160 --> 00:01:31,220

not devoid of oxygen that there was some

39
00:01:35,050 --> 00:01:33,170
small amount of oxygen in the in the

40
00:01:37,180 --> 00:01:35,060
oceans and oxygen Oasis or other such

41
00:01:38,800 --> 00:01:37,190
environments perhaps emanating into the

42
00:01:41,800 --> 00:01:38,810
atmosphere and being rapidly consumed by

43
00:01:43,330 --> 00:01:41,810
by oxidative weathering but the

44
00:01:45,160 --> 00:01:43,340
outstanding question you know yeah we

45
00:01:46,090 --> 00:01:45,170
have this kind of vision that that that

46
00:01:48,640 --> 00:01:46,100
it's an old vision and has become

47
00:01:50,860 --> 00:01:48,650
solidified but the extent of this

48
00:01:52,149 --> 00:01:50,870
oxygenation is poorly constrained and so

49
00:01:53,440 --> 00:01:52,159
this is the question that that has

50
00:01:55,810 --> 00:01:53,450
really interested Chad and he started

51
00:01:58,030 --> 00:01:55,820
thinking about whether or not thallium

52
00:01:59,230 --> 00:01:58,040
isotopes could be useful as a constraint

53
00:02:01,420 --> 00:01:59,240
which is what I'm gonna gonna present

54
00:02:04,510 --> 00:02:01,430
here or get to there have been a few

55
00:02:06,310 --> 00:02:04,520
other studies that really tried we've

56
00:02:09,669 --> 00:02:06,320
tried to get at this extent of

57
00:02:12,070 --> 00:02:09,679
oxygenation question in the oceans this

58
00:02:13,630 --> 00:02:12,080
work here in 2006 by John Eagan broad

59
00:02:16,539 --> 00:02:13,640
and Kate Freeman I made arguments based

60
00:02:18,250 --> 00:02:16,549
on carbon isotopes for extensive

61
00:02:19,869 --> 00:02:18,260
oxygenation on kondal margins a

62
00:02:20,770 --> 00:02:19,879
widespread oxygenation before the goe

63
00:02:26,140 --> 00:02:20,780

and

64
00:02:28,930 --> 00:02:26,150
rhenium enrichments not isotopes which

65
00:02:31,809 --> 00:02:28,940
is concentration enrichments in South

66
00:02:33,940 --> 00:02:31,819
African drill cores from about 2.6

67
00:02:36,160 --> 00:02:33,950
billion years ago to make the argument

68
00:02:37,540 --> 00:02:36,170
that there was oxygenation down to the

69
00:02:38,260 --> 00:02:37,550
sediment water interface at least in

70
00:02:41,080 --> 00:02:38,270
that location

71
00:02:42,340 --> 00:02:41,090
which promotes rhenium burial and the

72
00:02:44,920 --> 00:02:42,350
reef was the explanation of the Reem

73
00:02:46,240 --> 00:02:44,930
enrichment that Brian identified so

74
00:02:47,890 --> 00:02:46,250
there have been arguments made that

75
00:02:49,270 --> 00:02:47,900
oxygenation was extensive enough to

76
00:02:51,790 --> 00:02:49,280
actually give you fully oxygenated water

77
00:02:54,160 --> 00:02:51,800
columns on continental margins at least

78
00:02:56,800 --> 00:02:54,170
in some locations so that leads to

79
00:02:59,470 --> 00:02:56,810
prediction you you might predict then

80
00:03:01,000 --> 00:02:59,480
that if you really did have at least in

81
00:03:03,490 --> 00:03:01,010
some places and times fully oxygenated

82
00:03:06,820 --> 00:03:03,500
water columns that you would have had

83
00:03:11,860 --> 00:03:06,830
the ability to bury manganese oxides in

84
00:03:13,540 --> 00:03:11,870
in marginal sedimentary environments the

85
00:03:15,370 --> 00:03:13,550
basic idea being simply that in order to

86
00:03:16,900 --> 00:03:15,380
actually bury manganese and sequestered

87
00:03:19,509 --> 00:03:16,910
in sediments you need to have oxygen

88
00:03:21,610 --> 00:03:19,519

penetration in order to to allow for the

89
00:03:23,290 --> 00:03:21,620
preservation of mameys oxides during the

90
00:03:24,670 --> 00:03:23,300
burial process if you don't have oxygen

91
00:03:26,020 --> 00:03:24,680
penetration below the seventh water

92
00:03:28,900 --> 00:03:26,030
interface then you get the manganese

93
00:03:30,310 --> 00:03:28,910
cycling back out and so so chad

94
00:03:31,630 --> 00:03:30,320
speculated that well okay if these kind

95
00:03:33,280 --> 00:03:31,640
of environments were widespread we don't

96
00:03:34,360 --> 00:03:33,290
actually have those sediments so we have

97
00:03:35,530 --> 00:03:34,370
to look for them indirectly but if these

98
00:03:37,300 --> 00:03:35,540
kind environments are widespread with

99
00:03:38,530 --> 00:03:37,310
manganese oxides being buried perhaps

100
00:03:41,699 --> 00:03:38,540
there would be fingerprints of that that

101
00:03:43,810 --> 00:03:41,709
we could find in isotope systems now

102
00:03:45,670 --> 00:03:43,820
we've done some work previously to this

103
00:03:47,800 --> 00:03:45,680
with the notion that molybdenum isotopes

104
00:03:49,110 --> 00:03:47,810
might be useful for this and the basic

105
00:03:52,270 --> 00:03:49,120
concept for molybdenum isotopes

106
00:03:55,000 --> 00:03:52,280
schematically is that we know that

107
00:03:56,560 --> 00:03:55,010
melibea MYSA topes adsorb on to or

108
00:03:57,789 --> 00:03:56,570
molybdenum absorbs onto manganese oxides

109
00:03:59,500 --> 00:03:57,799
and there's an isotope fractionation

110
00:04:01,120 --> 00:03:59,510
when that happens such that light

111
00:04:03,340 --> 00:04:01,130
molybdenum I saw the light molybdenum is

112
00:04:05,289 --> 00:04:03,350
preferentially buried with manganese

113
00:04:07,030 --> 00:04:05,299

oxides leaving seawater heavy as a

114
00:04:08,680 --> 00:04:07,040
result and in fact modern seawater ship

115
00:04:10,509 --> 00:04:08,690
is substantially heavy word compared to

116
00:04:12,699 --> 00:04:10,519
the middle of my step composition River

117
00:04:14,170 --> 00:04:12,709
inputs because of this process going on

118
00:04:15,779 --> 00:04:14,180
today because we have copious manganese

119
00:04:18,610 --> 00:04:15,789
oxide deposition on the seafloor today

120
00:04:19,870 --> 00:04:18,620
so if you have environments for oxygen

121
00:04:22,690 --> 00:04:19,880
penetrates a sediment water in your face

122
00:04:23,980 --> 00:04:22,700
and and you bury manganese oxides you

123
00:04:25,540 --> 00:04:23,990
should preferentially sequester light

124
00:04:28,570 --> 00:04:25,550
molybdenum leaving the oceans heavy and

125
00:04:30,100 --> 00:04:28,580
you can sample that you can probe for in

126
00:04:31,659 --> 00:04:30,110
theory in principle you can probe for

127
00:04:34,510 --> 00:04:31,669
the seawater will have my Stoke

128
00:04:35,830 --> 00:04:34,520
composition by looking at live my stoop

129
00:04:37,950 --> 00:04:35,840
lived in my isotope composition in

130
00:04:39,850 --> 00:04:37,960
sediments deposited under uke ciinic

131
00:04:42,040 --> 00:04:39,860
conditions at least in those places

132
00:04:43,689 --> 00:04:42,050
where the water masses have enough time

133
00:04:46,559 --> 00:04:43,699
for the quantitative removal of the

134
00:04:49,029 --> 00:04:46,569
molybdenum in those environments and so

135
00:04:50,770 --> 00:04:49,039
we and others in pursue a little MYSA

136
00:04:52,540 --> 00:04:50,780
topes with that in mind this is worked

137
00:04:55,540 --> 00:04:52,550
by a former graduate student you and

138
00:04:56,770 --> 00:04:55,550

Juan in 2010 in the McCray Shale so

139
00:04:59,619 --> 00:04:56,780
here's the same thing you saw before the

140
00:05:00,820 --> 00:04:59,629
molybdenum enrichments around 2.5

141
00:05:02,409 --> 00:05:00,830
billion years ago in the mountain crazy

142
00:05:03,520 --> 00:05:02,419
Shale down here you have very little

143
00:05:06,460 --> 00:05:03,530
molybdenum then you have this

144
00:05:07,960 --> 00:05:06,470
this increase which is the the original

145
00:05:09,909 --> 00:05:07,970
signature of this width of oxygen

146
00:05:11,529 --> 00:05:09,919
concept and here are molybdenum isotopes

147
00:05:14,320 --> 00:05:11,539
and you can see there's a shift to

148
00:05:16,600 --> 00:05:14,330
heavier values here somewhat correlated

149
00:05:18,520 --> 00:05:16,610
with this these Malinin Richman's and

150
00:05:21,040 --> 00:05:18,530
the argument was made that this shift to

151
00:05:22,390 --> 00:05:21,050
heavier my stove values is indicative of

152
00:05:24,850 --> 00:05:22,400
a shift to heavier moving isotope values

153
00:05:27,790 --> 00:05:24,860
in the oceans being sampled at this time

154
00:05:29,230 --> 00:05:27,800
and that that is due to removable

155
00:05:30,909 --> 00:05:29,240
preference removal of light molybdenum

156
00:05:33,820 --> 00:05:30,919
oxidative environments perhaps including

157
00:05:36,010 --> 00:05:33,830
manganese oxides at the segment water

158
00:05:37,330 --> 00:05:36,020
interface in some places so that was one

159
00:05:39,309 --> 00:05:37,340
of the ideas put forward in this paper

160
00:05:41,170 --> 00:05:39,319
but there are number of ambiguities with

161
00:05:42,879 --> 00:05:41,180
little isotopes there also absorb up to

162
00:05:44,640 --> 00:05:42,889
iron oxides it's not a unique tracer for

163
00:05:46,719 --> 00:05:44,650

manganese in this fractionation there -

164
00:05:48,070 --> 00:05:46,729
there's complexation oblivion with

165
00:05:50,769 --> 00:05:48,080
organic matter that can also impart its

166
00:05:52,149 --> 00:05:50,779
- fractionation and in even in these

167
00:05:54,010 --> 00:05:52,159
your clinic settings if you don't have

168
00:05:55,390 --> 00:05:54,020
complete removal of molybdenum there's a

169
00:05:57,279 --> 00:05:55,400
nice dip fractionation with molybdenum

170
00:05:59,230 --> 00:05:57,289
forms thio molybdate saw Roxy time lib

171
00:06:00,640 --> 00:05:59,240
dates so if you don't complete removal

172
00:06:02,260 --> 00:06:00,650
you can get fractionation even in these

173
00:06:03,339 --> 00:06:02,270
reduced environments that are supposed

174
00:06:05,469 --> 00:06:03,349
to be where you're well you're getting a

175
00:06:07,029 --> 00:06:05,479
good record of the sea water value so

176
00:06:08,680 --> 00:06:07,039
there number of ambiguities with with

177
00:06:10,120 --> 00:06:08,690
moving my Stokes that always left a

178
00:06:11,620 --> 00:06:10,130
question mark about what what that what

179
00:06:13,719 --> 00:06:11,630
that shift to heavy values really means

180
00:06:16,269 --> 00:06:13,729
other than in general that has to do

181
00:06:17,649 --> 00:06:16,279
with oxidation probably so a family my

182
00:06:18,999 --> 00:06:17,659
stuff's come into play in this way this

183
00:06:21,939 --> 00:06:19,009
is a slightly complicated system but

184
00:06:23,769 --> 00:06:21,949
I'll try to give you the this simple the

185
00:06:26,019 --> 00:06:23,779
simple message out of it so first of all

186
00:06:29,230 --> 00:06:26,029
we took we talked in terms of the 205 to

187
00:06:31,059 --> 00:06:29,240
203 ratio that it's a very small

188
00:06:32,589 --> 00:06:31,069

variation so it's an epsilon units 10 to

189
00:06:35,110 --> 00:06:32,599
the 4 rather than Delta units 10 to the

190
00:06:36,640 --> 00:06:35,120
3 Salim comes in from a number of

191
00:06:38,379 --> 00:06:36,650
sources while Kanak gases rivers

192
00:06:40,629 --> 00:06:38,389
hydrothermal vents aerosols into

193
00:06:42,850 --> 00:06:40,639
seawater gets removed primarily into

194
00:06:45,610 --> 00:06:42,860
three sinks it gets removed in

195
00:06:48,270 --> 00:06:45,620
association with manganese oxides that's

196
00:06:50,860 --> 00:06:48,280
kind of key it also gets removed during

197
00:06:52,270 --> 00:06:50,870
alteration of ocean crust that's a net

198
00:06:54,520 --> 00:06:52,280
sink for a thallium from the sip from

199
00:06:56,589 --> 00:06:54,530
the oceans and it gets remove very

200
00:06:57,939 --> 00:06:56,599
efficiently into an toxic sedimentary

201
00:07:01,600 --> 00:06:57,949
environments where you have some sulfide

202
00:07:04,749 --> 00:07:01,610
in the water column the key to the story

203
00:07:06,429 --> 00:07:04,759
here is that when Sally me is removed

204
00:07:09,610 --> 00:07:06,439
into these manganese oxide environments

205
00:07:12,309 --> 00:07:09,620
there is a very strong fractionation 13

206
00:07:14,439 --> 00:07:12,319
epsilon units here verses -2 in the

207
00:07:16,600 --> 00:07:14,449
input and -6 and sea waters there's a

208
00:07:18,279 --> 00:07:16,610
very strong shift strong preferential

209
00:07:20,439 --> 00:07:18,289
removal of heavy thallium into these

210
00:07:23,550 --> 00:07:20,449
sediments leaving seawater light this is

211
00:07:28,059 --> 00:07:23,560
the big fractionation in the system and

212
00:07:31,330 --> 00:07:28,069
in these reducing environments thallium

213
00:07:32,619 --> 00:07:31,340

seems to be very nicely a very nice

214
00:07:34,119 --> 00:07:32,629
recorder of the seawater isotope

215
00:07:37,420 --> 00:07:34,129
composition there does not seem to be

216
00:07:38,589 --> 00:07:37,430
fractionation during removal into these

217
00:07:40,149 --> 00:07:38,599
environments these environments

218
00:07:41,680 --> 00:07:40,159
sediments deposit and these environments

219
00:07:44,200 --> 00:07:41,690
can be pretty good probe of seawater and

220
00:07:45,279 --> 00:07:44,210
the seawater ISTEP composition we think

221
00:07:47,260 --> 00:07:45,289
should vary as a function of how

222
00:07:50,260 --> 00:07:47,270
importance this manganese oxide burial

223
00:07:53,260 --> 00:07:50,270
story is and this is this has been

224
00:07:55,089 --> 00:07:53,270
reviewed in and in a this nice paper in

225
00:07:56,950 --> 00:07:55,099
reviews numerology geochemistry there's

226
00:07:58,899 --> 00:07:56,960
been a number of studies building this

227
00:08:01,300 --> 00:07:58,909
up by suni Nielsen's group and and

228
00:08:02,740 --> 00:08:01,310
Jeremy and others critically the

229
00:08:04,269 --> 00:08:02,750
ambiguities the plague molybdenum

230
00:08:06,760 --> 00:08:04,279
isotopes don't plague thallium isotopes

231
00:08:08,409 --> 00:08:06,770
it appears as far as anybody can tell so

232
00:08:09,879 --> 00:08:08,419
far the family mice notes don't fraction

233
00:08:11,559 --> 00:08:09,889
ate during adsorption on to iron oxides

234
00:08:13,749 --> 00:08:11,569
for example so that ambiguity that is

235
00:08:15,129 --> 00:08:13,759
there with molybdenum is gone and

236
00:08:16,809 --> 00:08:15,139
thallium doesn't seem to form thio

237
00:08:18,249 --> 00:08:16,819
complexes and doesn't seem to be subject

238
00:08:20,800 --> 00:08:18,259

to this incomplete removal problem in

239
00:08:21,249 --> 00:08:20,810
reducing environments and so it's still

240
00:08:23,079 --> 00:08:21,259
early days

241
00:08:24,430 --> 00:08:23,089
all new proxies go through their wave of

242
00:08:26,200 --> 00:08:24,440
optimism but maybe we're still there

243
00:08:27,219 --> 00:08:26,210
with thallium but at least at the moment

244
00:08:30,070 --> 00:08:27,229
it seems to not have the same

245
00:08:32,290 --> 00:08:30,080
ambiguities in molybdenum and so the

246
00:08:33,699 --> 00:08:32,300
notion that Chad had was let's go and

247
00:08:36,699 --> 00:08:33,709
look and here's what he hypothesized we

248
00:08:38,050 --> 00:08:36,709
ought to see if you have environments

249
00:08:39,339 --> 00:08:38,060
where you have oxygen penetrating the

250
00:08:40,659 --> 00:08:39,349
sediment water interface and burial of

251
00:08:42,490 --> 00:08:40,669
Maggie's oxides you will preferentially

252
00:08:44,259 --> 00:08:42,500
sequester light isotopes haven't lived

253
00:08:45,939 --> 00:08:44,269
in them as we said before and you should

254
00:08:48,430 --> 00:08:45,949
preferentially sequester heavy isotopes

255
00:08:50,560 --> 00:08:48,440
of thallium that's what the other data

256
00:08:52,060 --> 00:08:50,570
shows so seawater in these kind of

257
00:08:53,740 --> 00:08:52,070
situations seawater should be driven

258
00:08:57,490 --> 00:08:53,750
towards heavy molybdenum ISTEP values

259
00:09:00,210 --> 00:08:57,500
and light thallium ISTEP values and we

260
00:09:01,910 --> 00:09:00,220
should be able to probe both of those in

261
00:09:04,460 --> 00:09:01,920
highly reducing

262
00:09:06,079 --> 00:09:04,470
sedimentary environments and what you

263
00:09:07,310 --> 00:09:06,089

should see then is a complimentary ship

264
00:09:08,870 --> 00:09:07,320
you should see these guys going sort of

265
00:09:11,210 --> 00:09:08,880
in opposite directions they should

266
00:09:13,269 --> 00:09:11,220
complement each other so you might

267
00:09:15,800 --> 00:09:13,279
expect to see if you go from go from a

268
00:09:18,230 --> 00:09:15,810
anoxic world a more oxidizing one you

269
00:09:21,470 --> 00:09:18,240
might expect to see that in in black

270
00:09:22,699 --> 00:09:21,480
shales which are this reduced complement

271
00:09:26,150 --> 00:09:22,709
to the oxides where we can actually

272
00:09:27,680 --> 00:09:26,160
track seawater we think you might expect

273
00:09:31,189 --> 00:09:27,690
to see then thallium going light

274
00:09:32,150 --> 00:09:31,199
molybdenum going heavy and microphones

275
00:09:34,400 --> 00:09:32,160
getting knocked around all sorts of

276
00:09:36,410 --> 00:09:34,410
stuff like that so that's what you might

277
00:09:38,060 --> 00:09:36,420
expect to see so what is what do we

278
00:09:40,519 --> 00:09:38,070
actually see then so this is work that

279
00:09:42,410 --> 00:09:40,529
was just published earlier this year in

280
00:09:43,939 --> 00:09:42,420
Nature Geoscience is so here is again

281
00:09:49,220 --> 00:09:43,949
this molybdenum enrichment and black

282
00:09:51,829 --> 00:09:49,230
shales here are slides here here's the

283
00:09:53,060 --> 00:09:51,839
molybdenum isotope values so Chad went

284
00:09:54,199 --> 00:09:53,070
and reimagined them live my steps at

285
00:09:56,990 --> 00:09:54,209
much higher resolutions there's a lot

286
00:09:58,490 --> 00:09:57,000
more live my scope data now so you can

287
00:09:59,990 --> 00:09:58,500
see this shift to heavier valleys of

288
00:10:01,370 --> 00:10:00,000

live and isotopes then shift back down

289
00:10:02,269 --> 00:10:01,380
and an interesting lee another shift up

290
00:10:02,600 --> 00:10:02,279
here trying to figure out what that

291
00:10:04,730 --> 00:10:02,610
means

292
00:10:06,980 --> 00:10:04,740
and here the thallium isotopes and you

293
00:10:10,100 --> 00:10:06,990
can see they mirror you know pretty

294
00:10:11,150 --> 00:10:10,110
nicely for this kind of work anyway to

295
00:10:12,259 --> 00:10:11,160
enough fill in your old sediments and

296
00:10:14,060 --> 00:10:12,269
although things have happened since then

297
00:10:16,220 --> 00:10:14,070
potentially there does seem to be this

298
00:10:18,860 --> 00:10:16,230
complementarity very much the way Chad

299
00:10:22,040 --> 00:10:18,870
predicted and you know it's it's

300
00:10:24,110 --> 00:10:22,050
geochemistry so trends but this is a

301
00:10:27,439 --> 00:10:24,120
significant trend right there's a

302
00:10:30,019 --> 00:10:27,449
correlation there so so the upshot then

303
00:10:32,329 --> 00:10:30,029
is it looks like we would argue that

304
00:10:33,380 --> 00:10:32,339
this is at least a strong argument to be

305
00:10:35,930 --> 00:10:33,390
made that what you're seeing here is

306
00:10:37,040 --> 00:10:35,940
evidence of not just small mats box in

307
00:10:39,769 --> 00:10:37,050
the environment but actually burial

308
00:10:41,180 --> 00:10:39,779
manganese oxides varalu manganese oxides

309
00:10:42,889 --> 00:10:41,190
- in extent it's significant enough that

310
00:10:45,170 --> 00:10:42,899
it's affecting the ocean budgets of both

311
00:10:46,819 --> 00:10:45,180
thallium and molybdenum so you can do

312
00:10:48,949 --> 00:10:46,829
some simple isotope mass balance

313
00:10:50,780 --> 00:10:48,959

modeling you can come up with for

314
00:10:51,949 --> 00:10:50,790
molybdenum isotopes at the fraction of

315
00:10:53,840 --> 00:10:51,959
molybdenum in the system that's being

316
00:10:55,660 --> 00:10:53,850
removed but mang-nese oxides at that

317
00:10:58,100 --> 00:10:55,670
time was something like 20 to 30 percent

318
00:10:59,600 --> 00:10:58,110
for thallium isotopes it's somewhere

319
00:11:00,590 --> 00:10:59,610
between six and twenty percent big

320
00:11:01,790 --> 00:11:00,600
uncertainties because there's a lot of

321
00:11:05,600 --> 00:11:01,800
uncertainties of course in the budgets

322
00:11:06,860 --> 00:11:05,610
these elements so but these are these

323
00:11:08,960 --> 00:11:06,870
are pretty significant they're smaller

324
00:11:11,569 --> 00:11:08,970
fractions than in the modern oceans but

325
00:11:14,389 --> 00:11:11,579
not dramatically smaller they're smaller

326
00:11:15,890 --> 00:11:14,399
by 10 or 20 percent or so so these are

327
00:11:18,020 --> 00:11:15,900
these are pretty sizable

328
00:11:19,730 --> 00:11:18,030
six inks and so it's hard to turn that

329
00:11:20,930 --> 00:11:19,740
into a quantitative measure that's that

330
00:11:23,030 --> 00:11:20,940
requires a lot better understanding of

331
00:11:25,520 --> 00:11:23,040
the site of the budgets which which are

332
00:11:26,990 --> 00:11:25,530
working on but what emerges more

333
00:11:29,350 --> 00:11:27,000
strongly than before is the notion that

334
00:11:31,850 --> 00:11:29,360
we might want to be thinking about

335
00:11:34,430 --> 00:11:31,860
Archaean environments in which you the

336
00:11:35,570 --> 00:11:34,440
the shelf environment was sufficiently

337
00:11:38,110 --> 00:11:35,580
oxygenated that you actually had

338
00:11:40,880 --> 00:11:38,120

manganese oxides being buried in

339
00:11:42,200 --> 00:11:40,890
sediments you had oxygen fully

340
00:11:44,480 --> 00:11:42,210
oxygenated water columns down to the

341
00:11:46,040 --> 00:11:44,490
water interface persistently for long

342
00:11:47,660 --> 00:11:46,050
periods of time in large parts of the

343
00:11:48,800 --> 00:11:47,670
ocean so when you think about oxygen

344
00:11:51,110 --> 00:11:48,810
Oasis you might really want to think

345
00:11:52,850 --> 00:11:51,120
about you know substantially oxygenated

346
00:11:54,890 --> 00:11:52,860
shelf environments for long periods of

347
00:11:57,800 --> 00:11:54,900
time coming and going and wafting and

348
00:12:10,370 --> 00:11:57,810
win and waning and so I will end there

349
00:12:12,530 --> 00:12:10,380
and take questions Thanks the whiffs of

350
00:12:15,470 --> 00:12:12,540
oxygen shorelines is that where you

351
00:12:17,330 --> 00:12:15,480
expect the most I guess cyanobacteria to

352
00:12:18,980 --> 00:12:17,340
be producing the oxygen it's a

353
00:12:23,600 --> 00:12:18,990
reasonable hypothesis is there any other

354
00:12:24,650 --> 00:12:23,610
hypothesis I mean if you interpret all

355
00:12:27,260 --> 00:12:24,660
this evidence as evidence of o2

356
00:12:28,820 --> 00:12:27,270
production by photosynthesis then

357
00:12:30,290 --> 00:12:28,830
presumably you're talking about santa

358
00:12:31,730 --> 00:12:30,300
bacteria growing those near shore arms

359
00:12:34,160 --> 00:12:31,740
is a very classic idea it's not a new

360
00:12:37,700 --> 00:12:34,170
idea right it's a no land anything oh

361
00:12:38,510 --> 00:12:37,710
the land question Don sitting right

362
00:12:40,010 --> 00:12:38,520
behind you might have a better idea

363
00:12:47,420 --> 00:12:40,020

what's on what might have been on land

364
00:12:53,090 --> 00:12:47,430
and I then then I do but yeah yeah do we

365
00:12:54,650 --> 00:12:53,100
want to believe it but but but again the

366
00:12:56,750 --> 00:12:54,660
fit but just give it back to the actual

367
00:12:58,670 --> 00:12:56,760
story here right the thallium isotopes

368
00:13:00,950 --> 00:12:58,680
are telling you about burial in the

369
00:13:02,420 --> 00:13:00,960
ocean environment right so yeah you

370
00:13:04,460 --> 00:13:02,430
could have had oxygen production on land

371
00:13:07,820 --> 00:13:04,470
you could have biological soil across I

372
00:13:10,280 --> 00:13:07,830
mean I by two but that wouldn't give you

373
00:13:12,110 --> 00:13:10,290
manganese oxide deposition very easily

374
00:13:13,670 --> 00:13:12,120
in the marginal environments I think you

375
00:13:15,560 --> 00:13:13,680
need to have oxygen actually in the

376
00:13:17,720 --> 00:13:15,570
water allowed as an exact size be

377
00:13:22,390 --> 00:13:17,730
preserved and buried that's what the

378
00:13:29,069 --> 00:13:26,400
I'm wondering if you actually need

379
00:13:31,889 --> 00:13:29,079
in the water or if you can do this

380
00:13:36,420 --> 00:13:31,899
process with oxygen production and

381
00:13:38,999 --> 00:13:36,430
benthic mats in these areas so one of

382
00:13:41,699 --> 00:13:39,009
the great things about benthic mats is

383
00:13:44,220 --> 00:13:41,709
that you concentrate the oxygen and can

384
00:13:47,429 --> 00:13:44,230
get very high values over extensive

385
00:13:52,670 --> 00:13:47,439
areas without actually oxidizing the

386
00:13:55,170 --> 00:13:52,680
water but and that oxygen does penetrate

387
00:13:56,100 --> 00:13:55,180
right no I think it's a good question I

388
00:13:58,199 --> 00:13:56,110

mean obviously that's gonna be

389
00:13:59,460 --> 00:13:58,209
restricted to a smaller part of the I

390
00:14:00,780 --> 00:13:59,470
mean the area's gonna be smaller because

391
00:14:02,730 --> 00:14:00,790
it has to be shallower because light has

392
00:14:04,079 --> 00:14:02,740
to penetrate but we don't have a good

393
00:14:06,660 --> 00:14:04,089
enough quantity but we don't have good

394
00:14:09,720 --> 00:14:06,670
enough quantity of you know idea to

395
00:14:10,559 --> 00:14:09,730
really to really get traction on that

396
00:14:12,300 --> 00:14:10,569
but I think that would be interesting

397
00:14:23,220 --> 00:14:12,310
question asked how much environment

398
00:14:25,889 --> 00:14:23,230
could you remember that way Amelia

399
00:14:28,639 --> 00:14:25,899
Hernandez UC Davis you've prevented

400
00:14:30,420 --> 00:14:28,649
you've presented a case of a stratified

401
00:14:32,040 --> 00:14:30,430
ocean at least in the nearshore

402
00:14:35,160 --> 00:14:32,050
environments

403
00:14:37,829 --> 00:14:35,170
what sort of physical processes are

404
00:14:40,139 --> 00:14:37,839
required to maintain the stratification

405
00:14:45,329 --> 00:14:40,149
like such as salinity as presented in

406
00:14:47,280 --> 00:14:45,339
the previous talk so I don't know how

407
00:14:48,449 --> 00:14:47,290
stable 'is stratified all this would

408
00:14:49,470 --> 00:14:48,459
have been these are kind of scenarios

409
00:14:50,970 --> 00:14:49,480
that I think would have been coming and

410
00:14:52,620 --> 00:14:50,980
going so I don't think you should be

411
00:14:53,929 --> 00:14:52,630
thinking of an ocean that is you know

412
00:14:56,999 --> 00:14:53,939
for a billion years

413
00:14:58,949 --> 00:14:57,009

oxidize the surface you clinic wedges

414
00:15:00,090 --> 00:14:58,959
and you know it's things are coming and

415
00:15:01,470 --> 00:15:00,100
going and moving and I think that's what

416
00:15:03,389 --> 00:15:01,480
that's what we see in the geologic

417
00:15:05,970 --> 00:15:03,399
record right we see this little

418
00:15:07,769 --> 00:15:05,980
miniature moons come and go so so what

419
00:15:10,170 --> 00:15:07,779
do you need you need to have a dynamic

420
00:15:14,309 --> 00:15:10,180
enough system where it doesn't get you

421
00:15:15,480 --> 00:15:14,319
know stuck but in terms of I mean you're

422
00:15:16,410 --> 00:15:15,490
asking specific like what salinity you

423
00:15:18,150 --> 00:15:16,420
need to have an oceans and how would

424
00:15:19,379 --> 00:15:18,160
that change things I mean the the

425
00:15:21,030 --> 00:15:19,389
dynamics would change if you change the

426
00:15:26,939 --> 00:15:21,040
salinity the rates of mixing would

427
00:15:30,509 --> 00:15:26,949
change you know so that's a good

428
00:15:31,499 --> 00:15:30,519
question hmm where do you go with I've

429
00:15:32,999 --> 00:15:31,509
looking at Stephanie cuz I'm trying to

430
00:15:36,550 --> 00:15:33,009
I'm thinking well we might move on to

431
00:15:39,580 --> 00:15:36,560
another talk sorry