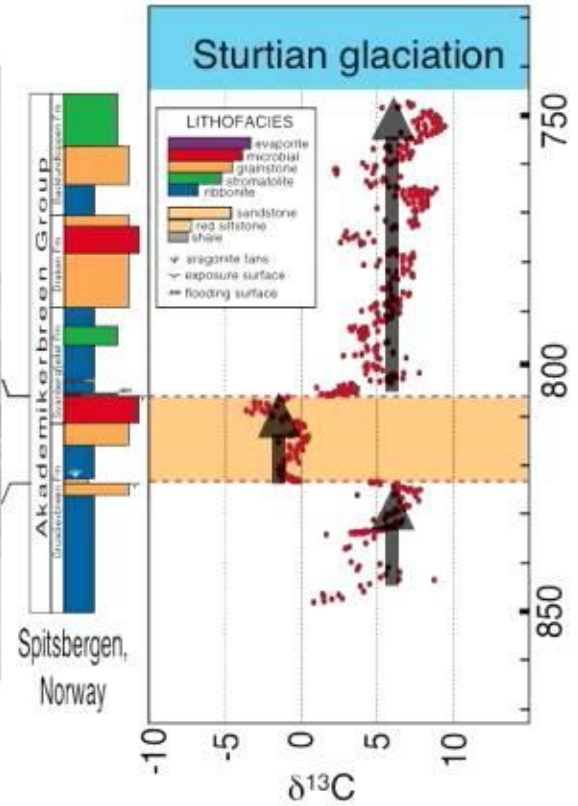

Courtesy Adam Maloof

1
00:00:06,309 --> 00:00:03,979
our speaker today is Joker Fink from

2
00:00:09,920 --> 00:00:06,319
Caltech where he is professor at

3
00:00:11,810 --> 00:00:09,930
geobiology Jose actually did his

4
00:00:16,210 --> 00:00:11,820
bachelor's degree at Caltech and then

5
00:00:19,400 --> 00:00:16,220
PhD at Princeton and he's an expert on

6
00:00:21,230 --> 00:00:19,410
paleo magnetism and he's done a number

7
00:00:26,540 --> 00:00:21,240
of made a number of discoveries related

8
00:00:31,310 --> 00:00:26,550
to astrobiology was originated of class

9
00:00:33,170 --> 00:00:31,320
snowball earth hypothesis and I think

10
00:00:35,420 --> 00:00:33,180
the last time I heard him talk here and

11
00:00:37,520 --> 00:00:35,430
you dubbed he was lecturing about

12
00:00:40,610 --> 00:00:37,530
whether a Martian meteorite was had

13
00:00:43,100 --> 00:00:40,620

evidence for for life and his topic

14
00:00:51,400 --> 00:00:43,110
today is four billion years of change

15
00:00:57,140 --> 00:00:54,650
well thank you for the invitation Steven

16
00:01:00,200 --> 00:00:57,150
and think you better reward for your

17
00:01:01,190 --> 00:01:00,210
toast and hospitality and proposal

18
00:01:06,739 --> 00:01:01,200
riding frenzy

19
00:01:09,560 --> 00:01:06,749
everything all right we're moving on it

20
00:01:14,599 --> 00:01:09,570
can people hear me OK or on the

21
00:01:16,880 --> 00:01:14,609
microphone yes no oh alright where's the

22
00:01:19,609 --> 00:01:16,890
microchip it on I don't have the

23
00:01:22,639 --> 00:01:19,619
strongest voice fortunately actually

24
00:01:25,429 --> 00:01:22,649
what I wanted to do today was to use the

25
00:01:46,280 --> 00:01:25,439
Precambrian to bring a climate lesson or

26
00:01:55,730 --> 00:01:51,240
is that better it's only four billion

27
00:01:58,920 --> 00:01:55,740
years of change which is something like

28
00:02:05,340 --> 00:01:58,930
170 million years for a minute they have

29
00:02:08,910 --> 00:02:05,350
to cover so what I would like to do is

30
00:02:10,770 --> 00:02:08,920
to first acknowledge the National

31
00:02:12,990 --> 00:02:10,780
Science Foundation NASA and the Aragon

32
00:02:15,780 --> 00:02:13,000
Institute for finding various bits of

33
00:02:17,940 --> 00:02:15,790
the work that I'm going to be talking

34
00:02:20,250 --> 00:02:17,950
about as well as a plethora of other

35
00:02:22,050 --> 00:02:20,260
core investigators that have been

36
00:02:25,500 --> 00:02:22,060
involved along the way don't name a few

37
00:02:29,550 --> 00:02:25,510
others that go but wanted to cover

38
00:02:31,890 --> 00:02:29,560

basically four things here you want all

39
00:02:34,710 --> 00:02:31,900
of what your lessons from what the earth

40
00:02:36,840 --> 00:02:34,720
can do in terms of climate change that

41
00:02:40,680 --> 00:02:36,850
we ought to worry about a little bit is

42
00:02:42,990 --> 00:02:40,690
the later bits of Earth history first

43
00:02:45,300 --> 00:02:43,000
the oxygen problem

44
00:02:50,750 --> 00:02:45,310
I want to talk about one of the oldest

45
00:02:53,449 --> 00:02:50,760
puzzles in metabolism and that is how

46
00:02:57,330 --> 00:02:53,459
organisms could evolve the ability to

47
00:02:59,040 --> 00:02:57,340
release molecular oxygen when there's

48
00:03:01,380 --> 00:02:59,050
almost no viable way of eating molecular

49
00:03:03,090 --> 00:03:01,390
oxygen in the environment in organically

50
00:03:05,340 --> 00:03:03,100
since the chicken and the egg problem in

51
00:03:07,470 --> 00:03:05,350
order to not poison yourself if you're

52
00:03:09,270 --> 00:03:07,480
releasing molecular oxygen have to get

53
00:03:11,370 --> 00:03:09,280
somewhere immediately it to have some

54
00:03:15,270 --> 00:03:11,380
way to mediate it have to be expensed to

55
00:03:17,729 --> 00:03:15,280
it so I think we have a rhythm of that

56
00:03:19,860 --> 00:03:17,739
and that bleeds into this whole problem

57
00:03:22,650 --> 00:03:19,870
with warm attitude glaciations or

58
00:03:25,860 --> 00:03:22,660
snowball earth states and I think the

59
00:03:28,440 --> 00:03:25,870
oxygen problem is one lead-in to the

60
00:03:30,810 --> 00:03:28,450
cause of at least one will add a new

61
00:03:33,509 --> 00:03:30,820
glaciation that we could argue semi

62
00:03:38,070 --> 00:03:33,519
convincingly and we have some idea of

63
00:03:41,729 --> 00:03:38,080

how to trigger a snowball and that leads

64
00:03:43,259 --> 00:03:41,739
into the other interval in geological

65
00:03:44,729 --> 00:03:43,269
time were there seem to be a low

66
00:03:46,259 --> 00:03:44,739
latitude glaciation is the Paleo

67
00:03:46,650 --> 00:03:46,269
reporter resort so we're talking about

68
00:03:48,390 --> 00:03:46,660
that

69
00:03:50,309 --> 00:03:48,400
the air flow reserve

70
00:03:53,449 --> 00:03:50,319
but the pillow runners up and then go to

71
00:03:56,580 --> 00:03:53,459
the neoproterozoic yeah there is a funny

72
00:03:58,589 --> 00:03:56,590
phenomenon that may be related to the

73
00:04:00,630 --> 00:03:58,599
wall other compilations and they not

74
00:04:04,890 --> 00:04:00,640
it's rearing its ugly head it's called

75
00:04:07,979 --> 00:04:04,900
trooper or wonder and I'm gonna actually

76
00:04:10,229 --> 00:04:07,989
try to push the edge of the envelope and

77
00:04:12,449 --> 00:04:10,239
make you convinced they're trying to

78
00:04:14,190 --> 00:04:12,459
convince you maybe that we might be able

79
00:04:16,500 --> 00:04:14,200
to get all solutions of up to two or

80
00:04:18,170 --> 00:04:16,510
three kilometers in your static sea

81
00:04:21,900 --> 00:04:18,180
level in the course of a million years

82
00:04:23,820 --> 00:04:21,910
and if you've got word from me maybe I

83
00:04:25,620 --> 00:04:23,830
can lead you down the road to think that

84
00:04:29,640 --> 00:04:25,630
something like that may have happened as

85
00:04:32,070 --> 00:04:29,650
young as the Cretaceous so that's true

86
00:04:34,020 --> 00:04:32,080
form under the Cretaceous at the end ok

87
00:04:39,080 --> 00:04:34,030
so let's start with the oxygen problem

88
00:04:45,439 --> 00:04:42,629

you're casting among others a lot of

89
00:04:48,450 --> 00:04:45,449
geologists worried about the atmosphere

90
00:04:50,700 --> 00:04:48,460
ocean atmosphere gases isn't it and they

91
00:04:52,529 --> 00:04:50,710
call geologists the Precambrian have

92
00:04:55,860 --> 00:04:52,539
tried to draw a graph like this at some

93
00:04:58,230 --> 00:04:55,870
point in your career where the oxygen

94
00:05:00,270 --> 00:04:58,240
may have risen what other gases may have

95
00:05:01,560 --> 00:05:00,280
been in there the castings models was

96
00:05:03,570 --> 00:05:01,570
probably a pretty good one for that

97
00:05:06,860 --> 00:05:03,580
there's a big question now about the

98
00:05:09,060 --> 00:05:06,870
origin of free oxygen in the atmosphere

99
00:05:10,620 --> 00:05:09,070
casting the good oxygen producing

100
00:05:12,779 --> 00:05:10,630
bacteria together so here basis

101
00:05:16,560 --> 00:05:12,789
biomarker evidence I want you that's

102
00:05:20,510 --> 00:05:16,570
probably not visible these days we know

103
00:05:22,920 --> 00:05:20,520
that there are methanogens about 3.5

104
00:05:26,670 --> 00:05:22,930
billion years mint paper last year by

105
00:05:30,150 --> 00:05:26,680
the way no and this is Aki Amazon others

106
00:05:32,460 --> 00:05:30,160
you can studying gases include

107
00:05:36,689 --> 00:05:32,470
inclusions from the Pilbara group I

108
00:05:38,339 --> 00:05:36,699
think the elegant paper but so the

109
00:05:40,230 --> 00:05:38,349
biological control of methane is at

110
00:05:42,240 --> 00:05:40,240
least that old but it really has more

111
00:05:43,650 --> 00:05:42,250
negative feedback in the atmosphere in

112
00:05:46,770 --> 00:05:43,660
the way that co2 does

113
00:05:49,200 --> 00:05:46,780

co2 of the climate warms up weathering

114
00:05:51,420 --> 00:05:49,210
increases productivity increases and

115
00:05:55,650 --> 00:05:51,430
pull down co2 methane doesn't seem to

116
00:05:57,450 --> 00:05:55,660
have that feedback the state of the

117
00:05:59,140 --> 00:05:57,460
atmosphere I think is even pretty

118
00:06:01,790 --> 00:05:59,150
clearly remain

119
00:06:04,610 --> 00:06:01,800
reducing this is just the software

120
00:06:09,650 --> 00:06:04,620
isotope data from Farquhar del up to

121
00:06:11,540 --> 00:06:09,660
about 2.5 2.4 when it dropped a little

122
00:06:13,700 --> 00:06:11,550
bit there's a nebulous interval here

123
00:06:16,940 --> 00:06:13,710
where we have glaciations and then we

124
00:06:19,909 --> 00:06:16,950
have a snowball and so the big question

125
00:06:21,440 --> 00:06:19,919
here is do these sterile biomarkers mean

126
00:06:24,050 --> 00:06:21,450
what they've been interpreted to mean

127
00:06:25,970 --> 00:06:24,060
both in terms of cyanobacteria markers

128
00:06:28,550 --> 00:06:25,980
in eukaryotes and whether they are

129
00:06:31,190 --> 00:06:28,560
indeed oxygen constraints or not there's

130
00:06:36,530 --> 00:06:31,200
a conflict the error kind of shows this

131
00:06:38,719 --> 00:06:36,540
very nice right where these Commandment

132
00:06:41,360 --> 00:06:38,729
I see I'd like to suggest that there may

133
00:06:42,680 --> 00:06:41,370
be an alternate explanation for that you

134
00:06:42,950 --> 00:06:42,690
know I should give the biochemistry of

135
00:06:45,550 --> 00:06:42,960
it

136
00:06:47,870 --> 00:06:45,560
so getting through Earth's climate and

137
00:06:51,250 --> 00:06:47,880
then getting back to this chicken and

138
00:06:54,200 --> 00:06:51,260

the egg problem I'd like to know that

139
00:06:56,530 --> 00:06:54,210
whatever it's very clear that the

140
00:06:59,180 --> 00:06:56,540
glaciation is my molar glaciation

141
00:07:02,240 --> 00:06:59,190
running budget changes and make them a

142
00:07:04,969 --> 00:07:02,250
community when we most likely did not

143
00:07:09,710 --> 00:07:04,979
have oxygen in the atmosphere presumably

144
00:07:12,290 --> 00:07:09,720
have an ozone screen that situation of

145
00:07:14,960 --> 00:07:12,300
having an anaerobic atmosphere with

146
00:07:17,210 --> 00:07:14,970
glaciations means that we had polar ice

147
00:07:21,320 --> 00:07:17,220
caps that were exposed to ultraviolet

148
00:07:24,560 --> 00:07:21,330
light and we had a student last year

149
00:07:27,290 --> 00:07:24,570
Danny Lang who did a very interesting

150
00:07:31,340 --> 00:07:27,300
thesis with my colleague yuk Yuen and I

151
00:07:33,460 --> 00:07:31,350
and Bob Hoffman I Hartman what I would

152
00:07:36,529 --> 00:07:33,470
do in terms of producing potentially

153
00:07:38,690 --> 00:07:36,539
hydrogen peroxides and oxygen solving

154
00:07:40,760 --> 00:07:38,700
this chicken in the egg problem it

155
00:07:44,719 --> 00:07:40,770
actually started with the analysis of

156
00:07:48,010 --> 00:07:44,729
the ozone hole from the term ozone

157
00:07:50,810 --> 00:07:48,020
mapping spectrometer satellite and

158
00:07:53,870 --> 00:07:50,820
various people there have Stewart and

159
00:07:55,400 --> 00:07:53,880
Ellen others have noticed that if you go

160
00:07:58,100 --> 00:07:55,410
back through the ice at the South Pole

161
00:08:00,260 --> 00:07:58,110
you actually start seeing the evidence

162
00:08:04,370 --> 00:08:00,270
of the earth both of them all get me up

163
00:08:08,110 --> 00:08:04,380

in the peroxide concentrations part boy

164
00:08:09,969 --> 00:08:08,120
pavilion in the in the ice and

165
00:08:12,010 --> 00:08:09,979
expand that out and actually see the

166
00:08:14,560 --> 00:08:12,020
Pacifica variation of the other moguls

167
00:08:17,460 --> 00:08:14,570
up and down up now and you can see that

168
00:08:20,860 --> 00:08:17,470
in the peroxide things so what Danny did

169
00:08:24,460 --> 00:08:20,870
was extrapolate this to the Proterozoic

170
00:08:26,950 --> 00:08:24,470
the artena in early Spooner zone because

171
00:08:30,129 --> 00:08:26,960
if you think about it the photochemical

172
00:08:32,170 --> 00:08:30,139
reactions that produce the peroxide also

173
00:08:35,920 --> 00:08:32,180
release hydrogen that escapes away or is

174
00:08:37,450 --> 00:08:35,930
eating this big debate about whether

175
00:08:40,110 --> 00:08:37,460
that goes on doesn't affect this

176
00:08:43,450 --> 00:08:40,120
analysis very much but the basic ideas

177
00:08:45,850 --> 00:08:43,460
sure you can get peroxides generated

178
00:08:47,829 --> 00:08:45,860
with ultraviolet light but that's not an

179
00:08:49,390 --> 00:08:47,839
environment very conducive to life

180
00:08:50,829 --> 00:08:49,400
because the ultraviolet light itself is

181
00:08:53,560 --> 00:08:50,839
going to kill anything that is up there

182
00:08:57,240 --> 00:08:53,570
trying to make use of that oxygen but

183
00:09:00,910 --> 00:08:57,250
what the ice does is interesting the

184
00:09:03,190 --> 00:09:00,920
peroxide vapor will freeze out at about

185
00:09:06,730 --> 00:09:03,200
minus 1 Celsius it'll diffuse it has a

186
00:09:09,280 --> 00:09:06,740
lifetime of about well paths mean path

187
00:09:11,050 --> 00:09:09,290
length of about 6 kilometers and few

188
00:09:13,570 --> 00:09:11,060

hours life so it can diffuse into the

189
00:09:17,590 --> 00:09:13,580
fern of the ice where it will freeze at

190
00:09:20,170 --> 00:09:17,600
about minus 1 as such it will build up

191
00:09:22,930 --> 00:09:20,180
its concentration in the ice while the

192
00:09:25,150 --> 00:09:22,940
ice forms and if you integrate over a

193
00:09:27,190 --> 00:09:25,160
polar ice cap and follow the I cycle

194
00:09:29,230 --> 00:09:27,200
through you get non-trivial levels of

195
00:09:31,600 --> 00:09:29,240
peroxides generated in that fashion

196
00:09:33,190 --> 00:09:31,610
effect if you do it for the macking in

197
00:09:35,019 --> 00:09:33,200
it snowball and I'll talk about next

198
00:09:38,050 --> 00:09:35,029
assuming there's no oxygen in the air

199
00:09:40,630 --> 00:09:38,060
time you may be able to build up you bar

200
00:09:43,870 --> 00:09:40,640
level equivalents of o2 which would be

201
00:09:45,490 --> 00:09:43,880
released when the ice melts anyway what

202
00:09:50,800 --> 00:09:45,500
I think is going on but we were thinking

203
00:09:56,470 --> 00:09:50,810
going on yes during these three her

204
00:09:57,970 --> 00:09:56,480
negotiations there will be trace amounts

205
00:10:00,310 --> 00:09:57,980
of peroxides being built up in the ice

206
00:10:02,829 --> 00:10:00,320
as those it carried down to the bottom

207
00:10:05,610 --> 00:10:02,839
of the ice front where it melts it'll be

208
00:10:07,570 --> 00:10:05,620
releasing peroxides which sea watering

209
00:10:11,470 --> 00:10:07,580
disproportionate back into water and

210
00:10:14,079 --> 00:10:11,480
Frio to providing a trace poison that

211
00:10:16,420 --> 00:10:14,089
the biosphere can interact with with so

212
00:10:18,190 --> 00:10:16,430
I think that's a mechanism for driving

213
00:10:21,100 --> 00:10:18,200

the evolution of these oxygen mediating

214
00:10:23,230 --> 00:10:21,110
enzymes the superoxide dismutase

215
00:10:26,740 --> 00:10:23,240
catalase no family of enzymes that

216
00:10:30,250 --> 00:10:26,750
control that which point would you have

217
00:10:32,320 --> 00:10:30,260
bugs I can do that you can imagine that

218
00:10:34,480 --> 00:10:32,330
photosystem two will somehow evolve and

219
00:10:38,200 --> 00:10:34,490
I want kill the wardens do it so it's

220
00:10:42,070 --> 00:10:38,210
kind of a paving the way for that and

221
00:10:44,230 --> 00:10:42,080
Danny is I think credited for realizing

222
00:10:49,270 --> 00:10:44,240
the connection between that very nicely

223
00:10:50,620 --> 00:10:49,280
so it kind of summarized there's still

224
00:10:56,560 --> 00:10:50,630
this question about the sterile

225
00:10:58,270 --> 00:10:56,570
biomarkers now we have is that maybe

226
00:11:00,460 --> 00:10:58,280
this interval the peroneal a schism

227
00:11:02,350 --> 00:11:00,470
where we started to evolve for the

228
00:11:04,780 --> 00:11:02,360
system doing it so quick you really took

229
00:11:07,990 --> 00:11:04,790
off and started working what about these

230
00:11:10,240 --> 00:11:08,000
sterile biomarkers I don't think the

231
00:11:13,330 --> 00:11:10,250
polar glaciation is going to be enough

232
00:11:15,820 --> 00:11:13,340
to supply oxygen to make all the sterols

233
00:11:18,490 --> 00:11:15,830
that might be in all the Precambrian

234
00:11:21,340 --> 00:11:18,500
biomarker localities so we need to worry

235
00:11:23,080 --> 00:11:21,350
about what's going on and but the

236
00:11:26,470 --> 00:11:23,090
intriguing thing is that if you go back

237
00:11:29,590 --> 00:11:26,480
and look at the biochemistry of many of

238
00:11:32,170 --> 00:11:29,600

the oxygen using enzymes a lot of them

239
00:11:33,430 --> 00:11:32,180
have a funky steps where they take the

240
00:11:35,830 --> 00:11:33,440
molecular out to them they couldn't

241
00:11:37,870 --> 00:11:35,840
convert it back into a peroxide and then

242
00:11:43,120 --> 00:11:37,880
the peroxide runs through the catalytic

243
00:11:44,830 --> 00:11:43,130
activities and it might be if hints that

244
00:11:46,960 --> 00:11:44,840
these things evolved through a peroxide

245
00:11:49,720 --> 00:11:46,970
the comedian initially you know really

246
00:11:52,720 --> 00:11:49,730
did well there are a couple fossil

247
00:11:56,670 --> 00:11:52,730
biomarker suggestions of o2 before the

248
00:11:59,860 --> 00:11:56,680
snowballs summons yong-ki hoping Logan

249
00:12:03,400 --> 00:11:59,870
we're using methyl hoechlin the two

250
00:12:07,870 --> 00:12:03,410
methyl no pains as a sign about term

251
00:12:10,630 --> 00:12:07,880
biomarker bit actually we now know from

252
00:12:16,060 --> 00:12:10,640
the work of styrsky and Newman at

253
00:12:18,250 --> 00:12:16,070
Caltech that a number of the non oxygen

254
00:12:22,030 --> 00:12:18,260
look for the synthetic purple bacteria

255
00:12:23,260 --> 00:12:22,040
also make the exact same compounds and

256
00:12:27,610 --> 00:12:23,270
of course that was known before this

257
00:12:29,650 --> 00:12:27,620
paper but what rash B and Newman have

258
00:12:32,020 --> 00:12:29,660
done is to grow those organisms and

259
00:12:33,530 --> 00:12:32,030
height h2 atmosphere and the high co2

260
00:12:35,660 --> 00:12:33,540
atmosphere and you start chain

261
00:12:39,949 --> 00:12:35,670
parameters the relative numbers of these

262
00:12:42,579 --> 00:12:39,959
health plans go way up so it's actually

263
00:12:44,689 --> 00:12:42,589

really not a good Parker the other

264
00:12:48,379 --> 00:12:44,699
markers for scientific during the other

265
00:12:54,680 --> 00:12:48,389
interesting thing is many of these Rob

266
00:12:57,050 --> 00:12:54,690
you there's also a question about

267
00:12:59,090 --> 00:12:57,060
whether it many of the sediments are

268
00:13:01,639 --> 00:12:59,100
greener you know this is the debate was

269
00:13:03,259 --> 00:13:01,649
and Fortescue coast and so forth but in

270
00:13:03,889 --> 00:13:03,269
the interesting observation just an

271
00:13:08,389 --> 00:13:03,899
observation

272
00:13:10,639 --> 00:13:08,399
none of the marine cyanobacteria make to

273
00:13:13,460 --> 00:13:10,649
methyl hope eggs as far as we know and

274
00:13:16,309 --> 00:13:13,470
so that's an interesting anomaly those

275
00:13:18,800 --> 00:13:16,319
are marine segments but anyway I don't

276
00:13:20,509 --> 00:13:18,810
think they're hoping too much more

277
00:13:25,879 --> 00:13:20,519
things are good

278
00:13:31,490 --> 00:13:25,889
and that leaves these sterols and you

279
00:13:34,809 --> 00:13:31,500
know as of years ago the 2-methyl hoping

280
00:13:37,309 --> 00:13:34,819
that alarm markers were thought to be

281
00:13:40,269 --> 00:13:37,319
indicative of eukaryotes which indeed

282
00:13:43,189 --> 00:13:40,279
they may be in but there's also a

283
00:13:44,870 --> 00:13:43,199
suggestion from the modern biochemistry

284
00:13:47,329 --> 00:13:44,880
that these things are oxygen-dependent

285
00:13:50,030 --> 00:13:47,339
and i've been having lots of fun arguing

286
00:13:57,370 --> 00:13:50,040
with Roger someone's about this one as

287
00:14:00,800 --> 00:13:57,380
has Blankenship about this and in fact

288
00:14:03,559 --> 00:14:00,810

it's brought up an actually an old topic

289
00:14:06,220 --> 00:14:03,569
in molecular evolution about gene

290
00:14:07,340 --> 00:14:06,230
replacement in anaerobic aerobic

291
00:14:10,400 --> 00:14:07,350
transitions

292
00:14:12,259 --> 00:14:10,410
this is pointed out actually in 1965 by

293
00:14:15,949 --> 00:14:12,269
a molecular biologist when they were

294
00:14:17,900 --> 00:14:15,959
Goldfine who basically stated gee there

295
00:14:20,870 --> 00:14:17,910
are these enzyme swaps that replace

296
00:14:22,429 --> 00:14:20,880
anaerobic enzymes for aerobic ones and

297
00:14:24,530 --> 00:14:22,439
the good reasons for that because a lot

298
00:14:26,750 --> 00:14:24,540
of the anaerobic enzymes use iron sulfur

299
00:14:30,079 --> 00:14:26,760
clusters that are poisoned by molecular

300
00:14:31,910 --> 00:14:30,089
oxygen so you can swap them out you

301
00:14:33,470 --> 00:14:31,920
basically make a more stable system some

302
00:14:35,629 --> 00:14:33,480
have not been swapped out like

303
00:14:39,230 --> 00:14:35,639
nitrogenases and things a lot of them

304
00:14:41,540 --> 00:14:39,240
have and if that swap out does not

305
00:14:43,710 --> 00:14:41,550
destroy a whole chain of reaction it

306
00:14:45,749 --> 00:14:43,720
just can basically take one enzyme in

307
00:14:49,050 --> 00:14:45,759
place it in an otherwise intact by

308
00:14:51,030 --> 00:14:49,060
chemical pathway and certainly there are

309
00:14:55,009 --> 00:14:51,040
examples of where this has changed and

310
00:14:57,650 --> 00:14:55,019
the one that my friendship sites

311
00:15:01,619 --> 00:14:57,660
probably is the huge synthesis pathway

312
00:15:04,050 --> 00:15:01,629
where there are seventeen steps in the

313
00:15:06,199 --> 00:15:04,060

heme chlorophyll synthesis you'd be the

314
00:15:08,129 --> 00:15:06,209
chlorophyll and he shared the first

315
00:15:10,350 --> 00:15:08,139
bunch of those to get him and then

316
00:15:13,379 --> 00:15:10,360
there's more for chlorophyll and there

317
00:15:15,740 --> 00:15:13,389
are three well-documented one-to-one

318
00:15:19,259 --> 00:15:15,750
swaps of anaerobic for oxygen enzymes

319
00:15:22,309 --> 00:15:19,269
317 steps where it's been done and in

320
00:15:26,600 --> 00:15:22,319
the actual corazon thing certainly the

321
00:15:29,009 --> 00:15:26,610
basic molecule that releases oxygen

322
00:15:33,269 --> 00:15:29,019
chlorophyll has an oxygen dependence

323
00:15:36,629 --> 00:15:33,279
stuff the same molecule was present in

324
00:15:38,160 --> 00:15:36,639
an anaerobic photosynthetic bacteria so

325
00:15:40,530 --> 00:15:38,170
they had to have been a way to do it it

326
00:15:44,300 --> 00:15:40,540
turns out people wouldn't look for it in

327
00:15:48,150 --> 00:15:44,310
the last written quarter step actually

328
00:15:50,939 --> 00:15:48,160
there's a water coming through so you

329
00:15:54,179 --> 00:15:50,949
mean there is a I play explanation for

330
00:15:56,369 --> 00:15:54,189
that the arsenic synthetic pathway for

331
00:15:57,960 --> 00:15:56,379
chlorophyll has changed from one that

332
00:16:01,290 --> 00:15:57,970
works anaerobically the one that

333
00:16:04,519 --> 00:16:01,300
actually requires oxygen so given that

334
00:16:08,900 --> 00:16:04,529
this is blankenship summary of this

335
00:16:11,249 --> 00:16:08,910
different gene swapping replacement and

336
00:16:16,410 --> 00:16:11,259
when you're at when you actually go to

337
00:16:18,809 --> 00:16:16,420
the database of gene replacements there

338
00:16:28,579 --> 00:16:18,819

aren't a lot of them sort of like 80

339
00:16:31,799 --> 00:16:28,589
sets of proteins of where an oxygen has

340
00:16:34,499 --> 00:16:31,809
an equivalent options we've ended up for

341
00:16:37,980 --> 00:16:34,509
the same conserved reaction it's really

342
00:16:39,689 --> 00:16:37,990
not a rare thing but chemically and in

343
00:16:41,910 --> 00:16:39,699
terms of the actual sterile sample

344
00:16:42,900 --> 00:16:41,920
system you scratch your head and go back

345
00:16:45,480 --> 00:16:42,910
to what we know about sterile

346
00:16:48,600 --> 00:16:45,490
biosynthesis and say well is there a

347
00:16:50,020 --> 00:16:48,610
plausible way to do this and really

348
00:16:54,400 --> 00:16:50,030
towards there's something really

349
00:16:55,900 --> 00:16:54,410
monkey wrench and actually I think there

350
00:16:59,350 --> 00:16:55,910
is a possible way so what I'm showing

351
00:17:02,290 --> 00:16:59,360
here is the million biosynthetic way in

352
00:17:05,290 --> 00:17:02,300
eukaryotes we start with this when your

353
00:17:08,740 --> 00:17:05,300
snake-like molecule called squalor and

354
00:17:11,830 --> 00:17:08,750
in eukaryotes it gets oxygenated between

355
00:17:15,790 --> 00:17:11,840
the two and three prime units here and

356
00:17:17,710 --> 00:17:15,800
it ends up squealing epoxide it there's

357
00:17:23,140 --> 00:17:17,720
an oxygen dependent stuff in this thing

358
00:17:28,660 --> 00:17:23,150
which the oxygen and that when it gets

359
00:17:30,780 --> 00:17:28,670
cyclized in there and then there are a

360
00:17:33,400 --> 00:17:30,790
number of steps that convert that to

361
00:17:37,720 --> 00:17:33,410
when Estero and then while I stall is

362
00:17:40,930 --> 00:17:37,730
further oxidized methyl groups to get it

363
00:17:43,330 --> 00:17:40,940

to a guest role which then is the

364
00:17:45,700 --> 00:17:43,340
compound that you can actually feed it a

365
00:17:47,170 --> 00:17:45,710
yeast on anaerobically at that point you

366
00:17:53,020 --> 00:17:47,180
don't need oxygen for used girl friendly

367
00:17:54,610 --> 00:17:53,030
work and so question is mean that that's

368
00:17:57,010 --> 00:17:54,620
just showing that you remove these three

369
00:17:58,870 --> 00:17:57,020
methyl groups you give to the compounds

370
00:18:00,760 --> 00:17:58,880
that East you're happy with so question

371
00:18:02,650 --> 00:18:00,770
is is there a positive way of doing that

372
00:18:05,860 --> 00:18:02,660
without oxygen that can be swapped in

373
00:18:08,080 --> 00:18:05,870
and I say yes and the way I would do

374
00:18:10,990 --> 00:18:08,090
that if I were designed to get would be

375
00:18:13,780 --> 00:18:11,000
to simply first shift this scaling up

376
00:18:16,180 --> 00:18:13,790
oxide this is the one step that seems to

377
00:18:16,720 --> 00:18:16,190
be really molecular dependent but you

378
00:18:19,810 --> 00:18:16,730
don't need it

379
00:18:23,080 --> 00:18:19,820
so here's an alternative we'll do that

380
00:18:28,030 --> 00:18:23,090
again you wipe that out you go directly

381
00:18:30,130 --> 00:18:28,040
from swingley to this intermediate and

382
00:18:32,710 --> 00:18:30,140
if you really need a hydroxyl group here

383
00:18:35,380 --> 00:18:32,720
you can put it on from water that's a

384
00:18:38,140 --> 00:18:35,390
process that biochemistry is known for -

385
00:18:39,840 --> 00:18:38,150
all four proteins to do were easily you

386
00:18:43,960 --> 00:18:39,850
can extract a hydrogen and put a

387
00:18:46,710 --> 00:18:43,970
hydroxyl on it from water so you avoid

388
00:18:49,840 --> 00:18:46,720

that whole step of swimming on oxygen

389
00:18:51,790 --> 00:18:49,850
and then to go further down the chain

390
00:18:53,710 --> 00:18:51,800
well what about removing those metals

391
00:18:55,540 --> 00:18:53,720
gee you look at the literature in

392
00:18:57,250 --> 00:18:55,550
biochemistry there are these three other

393
00:18:59,590 --> 00:18:57,260
ways of removing methyl groups that

394
00:19:00,860 --> 00:18:59,600
don't require oxygen you can do it with

395
00:19:01,880 --> 00:19:00,870
radical serum

396
00:19:04,610 --> 00:19:01,890
actions which I'll get to an event

397
00:19:06,590 --> 00:19:04,620
fumarate based enzymes are even

398
00:19:10,640 --> 00:19:06,600
cobalamin vitamin b12 is a very good

399
00:19:12,350 --> 00:19:10,650
move around methyl groups so I don't

400
00:19:14,600 --> 00:19:12,360
think any of those are insurmountable in

401
00:19:17,660 --> 00:19:14,610
terms of the known biochemistry what we

402
00:19:19,340 --> 00:19:17,670
don't have is an organism that does the

403
00:19:21,290 --> 00:19:19,350
whole sturluson persistent aerobic life

404
00:19:23,330 --> 00:19:21,300
it may not have survived but it doesn't

405
00:19:26,980 --> 00:19:23,340
mean it wouldn't exist but at least some

406
00:19:29,270 --> 00:19:26,990
of them an example with these things and

407
00:19:34,240 --> 00:19:29,280
hydroxylation as you mentioned there are

408
00:19:39,740 --> 00:19:34,250
processes that take water and put on

409
00:19:42,650 --> 00:19:39,750
things and ethylbenzene dehydrogenase is

410
00:19:44,770 --> 00:19:42,660
one example then you can argue one way

411
00:19:47,540 --> 00:19:44,780
or another but there are iron sulfur

412
00:19:49,010 --> 00:19:47,550
actually melodium iron sulfur humans are

413
00:19:51,260 --> 00:19:49,020

used to do that their whole new category

414
00:19:55,070 --> 00:19:51,270
of sulfur based chemistry that's only

415
00:19:57,710 --> 00:19:55,080
being resolved now these are radical Sam

416
00:20:00,230 --> 00:19:57,720
reactions are another way yes I did on

417
00:20:07,070 --> 00:20:00,240
the final and binding incision things

418
00:20:12,320 --> 00:20:07,080
that you basically to do rather amazing

419
00:20:13,990 --> 00:20:12,330
hydrogen atom extraction reactions in

420
00:20:17,510 --> 00:20:14,000
other words the big problem is pulling

421
00:20:19,900 --> 00:20:17,520
hydrogens off of backbone carbon

422
00:20:23,419 --> 00:20:19,910
compounds and then moving them around

423
00:20:26,000 --> 00:20:23,429
but even though the reaction mechanism

424
00:20:28,669 --> 00:20:26,010
is not totally known it is known that

425
00:20:30,860 --> 00:20:28,679
these sulfur reduce itself introducing

426
00:20:33,520 --> 00:20:30,870
organisms are able to do some amazing

427
00:20:37,490 --> 00:20:33,530
things this is just a cable unwinding

428
00:20:40,370 --> 00:20:37,500
through that first how'd you get

429
00:20:43,010 --> 00:20:40,380
extraction and the ones that are known

430
00:20:44,690 --> 00:20:43,020
experimentally you go all the way up to

431
00:20:48,169 --> 00:20:44,700
hundred and thirteen

432
00:20:51,470 --> 00:20:48,179
telecom per mole activation energy for

433
00:20:53,419 --> 00:20:51,480
example the whole the other ones you're

434
00:20:56,020 --> 00:20:53,429
not really limited by being only at the

435
00:20:59,390 --> 00:20:56,030
terminal carbon or some terminal carbon

436
00:21:01,010 --> 00:20:59,400
at least the kinetics of the radical

437
00:21:03,500 --> 00:21:01,020
some reactions can go to almost any

438
00:21:04,850 --> 00:21:03,510

carbon assuming that the radical is

439
00:21:09,650 --> 00:21:04,860
focused properly and that would have to

440
00:21:11,869 --> 00:21:09,660
be done by an enzyme so I guess I don't

441
00:21:15,859 --> 00:21:11,879
buy sterols

442
00:21:17,359 --> 00:21:15,869
as an indicator of abundant oxygen and

443
00:21:19,849 --> 00:21:17,369
it's something better to prove that

444
00:21:21,469 --> 00:21:19,859
particularly when you find them in times

445
00:21:25,189 --> 00:21:21,479
when there's good evidence of marched in

446
00:21:29,629 --> 00:21:25,199
the atmosphere so a little attitude

447
00:21:32,769 --> 00:21:29,639
glaciation then quickly review a little

448
00:21:35,209 --> 00:21:32,779
bit of what we know immediately after

449
00:21:38,029 --> 00:21:35,219
this interval in the huronian at least

450
00:21:42,709 --> 00:21:38,039
capping it imagine a negotiation I'll

451
00:21:45,559 --> 00:21:42,719
talk about in South Africa the backbone

452
00:21:48,349 --> 00:21:45,569
is most of these sediments coming right

453
00:21:50,029 --> 00:21:48,359
after this unconformity here displayed

454
00:21:52,549 --> 00:21:50,039
mass independent sulphur isotope

455
00:21:54,529 --> 00:21:52,559
fractionation there's a little bit

456
00:21:57,289 --> 00:21:54,539
manganese that comes up in this sort of

457
00:21:59,869 --> 00:21:57,299
the Congo supergroup which we managed to

458
00:22:05,359 --> 00:21:59,879
get through the Agron drilling project

459
00:22:07,579 --> 00:22:05,369
which were rolling the youngest son

460
00:22:09,739 --> 00:22:07,589
backing any materials and there's little

461
00:22:12,109 --> 00:22:09,749
bit manganese that come in then end up

462
00:22:14,539 --> 00:22:12,119
for that glaciation it's capped by a

463
00:22:17,569 --> 00:22:14,549

flood basalt and some interesting things

464
00:22:19,999 --> 00:22:17,579
in the hottest held the formation

465
00:22:23,509 --> 00:22:20,009
efforts let's try exactly I'm going to

466
00:22:25,419 --> 00:22:23,519
talk briefly about this not hopefully

467
00:22:31,119 --> 00:22:25,429
convince you it's a glacial feature

468
00:22:33,499 --> 00:22:31,129
therefore next year dissolve formation

469
00:22:36,079 --> 00:22:33,509
capture which we interpret to be the

470
00:22:38,479 --> 00:22:36,089
snowball aftermath it's also got the

471
00:22:43,489 --> 00:22:38,489
largest fingerprint for oxygen that

472
00:22:45,919 --> 00:22:43,499
we've seen yet - and I think we

473
00:22:50,029 --> 00:22:45,929
understand it a bit more particularly in

474
00:22:52,159 --> 00:22:50,039
terms of dented plants probably not that

475
00:22:54,469 --> 00:22:52,169
much manganese you need oxygen if any

476
00:22:57,109 --> 00:22:54,479
way is right the Makani snowball could

477
00:22:59,749 --> 00:22:57,119
have released an atmosphere equivalent

478
00:23:01,759 --> 00:22:59,759
about two during the snowball aftermath

479
00:23:04,639 --> 00:23:01,769
and it may help explain how things got

480
00:23:07,159 --> 00:23:04,649
some ways oxidized perfectly believe

481
00:23:10,989 --> 00:23:07,169
that manganese field this is a site a

482
00:23:13,309 --> 00:23:10,999
cobble from the mcenany x distinguished

483
00:23:17,569 --> 00:23:13,319
presumably drug along the bottom of the

484
00:23:19,930 --> 00:23:17,579
glacier with many fishy facets and then

485
00:23:22,819 --> 00:23:19,940
actually has been contentious the

486
00:23:24,640 --> 00:23:22,829
results that go on top of it

487
00:23:26,260 --> 00:23:24,650
typical basaltic and aside

488
00:23:28,840 --> 00:23:26,270

like any other flood basalt in Earth

489
00:23:32,560 --> 00:23:28,850
history we think they probably came out

490
00:23:36,010 --> 00:23:32,570
in a few million years at most the time

491
00:23:39,310 --> 00:23:36,020
for the snowball if you just worry about

492
00:23:40,720 --> 00:23:39,320
volcanic outgassing building up a co2

493
00:23:43,660 --> 00:23:40,730
greenhouse to get out of it it's

494
00:23:45,070 --> 00:23:43,670
probably 50 to 100 million years at that

495
00:23:47,770 --> 00:23:45,080
interval time because there's solar

496
00:23:50,370 --> 00:23:47,780
constants 84 percent of President so

497
00:23:52,120 --> 00:23:50,380
that's why you can build up a lot of

498
00:23:54,610 --> 00:23:52,130
peroxides in the snow

499
00:24:05,380 --> 00:23:54,620
you know the poles are very nice for

500
00:24:07,900 --> 00:24:05,390
magnetics and for sleeping trees very

501
00:24:13,000 --> 00:24:07,910
good commandant test and two polarities

502
00:24:15,250 --> 00:24:13,010
present and you might say well going

503
00:24:17,320 --> 00:24:15,260
back this far in time I was really sure

504
00:24:20,770 --> 00:24:17,330
that the magnetic field and the earth is

505
00:24:22,450 --> 00:24:20,780
behaving itself and I point people who

506
00:24:25,240 --> 00:24:22,460
several people asked me at lunch today

507
00:24:27,670 --> 00:24:25,250
whether there was a chance the Earth's

508
00:24:30,100 --> 00:24:27,680
magnetic field might even on dipolar or

509
00:24:32,830 --> 00:24:30,110
maybe the obliquity retires over there

510
00:24:36,700 --> 00:24:32,840
why does it beethoven's paper in a

511
00:24:39,520 --> 00:24:36,710
nature last of the paper where he

512
00:24:42,490 --> 00:24:39,530
basically showed that the about rights

513
00:24:45,430 --> 00:24:42,500

are very consistent for the last two

514
00:24:50,740 --> 00:24:45,440
billion years of Earth history and

515
00:24:52,590 --> 00:24:50,750
precludes a high obliquity and or non

516
00:24:54,280 --> 00:24:52,600
dipolar field components causes

517
00:24:56,620 --> 00:24:54,290
discrimination it's a very nice paper

518
00:24:59,860 --> 00:24:56,630
and so if you get rid of my orbital

519
00:25:02,530 --> 00:24:59,870
equity and non dico field you're really

520
00:25:03,940 --> 00:25:02,540
left with a spinning snowball and it's

521
00:25:06,100 --> 00:25:03,950
the explanation from the robotic

522
00:25:09,640 --> 00:25:06,110
glaciations in at the present time

523
00:25:12,420 --> 00:25:09,650
that's the reason most reasonable most

524
00:25:19,810 --> 00:25:12,430
reasonable unreasonable hypothesis

525
00:25:28,340 --> 00:25:23,390
yeah the back lights tend to be confined

526
00:25:31,790 --> 00:25:28,350
to the subtropical belts kind of like

527
00:25:33,410 --> 00:25:31,800
where Africa is today or Arizona is and

528
00:25:36,980 --> 00:25:33,420
that's really about rights in the build

529
00:25:39,410 --> 00:25:36,990
up its has to do with the angle of the

530
00:25:40,880 --> 00:25:39,420
Sun relative to solar insolation and

531
00:25:44,420 --> 00:25:40,890
what David did is he went through all

532
00:25:47,540 --> 00:25:44,430
Mon evaporites through time particularly

533
00:25:50,210 --> 00:25:47,550
those for which there had been a very

534
00:25:52,070 --> 00:25:50,220
reliable telling magnetic data for that

535
00:25:55,460 --> 00:25:52,080
conduct for that place and for that time

536
00:25:57,800 --> 00:25:55,470
and actually went out and did a couple

537
00:26:01,700 --> 00:25:57,810
you know filming a couple holes with it

538
00:26:04,880 --> 00:26:01,710

is what he finds is that bears persists

539
00:26:06,380 --> 00:26:04,890
over the last two billion years and

540
00:26:08,020 --> 00:26:06,390
Teddy reggaeton wrote a very nice

541
00:26:09,980 --> 00:26:08,030
commentary on this and said yeah

542
00:26:12,380 --> 00:26:09,990
magnetic field has been the same old

543
00:26:19,430 --> 00:26:12,390
thing for the last 20 years

544
00:26:22,490 --> 00:26:19,440
what do ya not nice paper and again if

545
00:26:25,490 --> 00:26:22,500
it is a snowball a few colors maybe ice

546
00:26:27,650 --> 00:26:25,500
did reach the equator the pack ice would

547
00:26:29,720 --> 00:26:27,660
seal off the oceans you would get

548
00:26:33,650 --> 00:26:29,730
hydrothermal activity and volcanic

549
00:26:36,920 --> 00:26:33,660
activity going you build up iron and

550
00:26:39,350 --> 00:26:36,930
manganese in the in the subsea oceans if

551
00:26:41,090 --> 00:26:39,360
you get the banded iron stones form yeah

552
00:26:42,260 --> 00:26:41,100
because there's a lot of manganese

553
00:26:44,870 --> 00:26:42,270
coming out of those you would explain

554
00:26:47,120 --> 00:26:44,880
not only the trace element fingerprint

555
00:26:48,830 --> 00:26:47,130
of the bits associated with these things

556
00:26:54,950 --> 00:26:48,840
but you explain the manganese deposits

557
00:26:57,350 --> 00:26:54,960
and when is hoffman and rag2 explained

558
00:26:59,330 --> 00:26:57,360
in the 98 paper you would explain the

559
00:27:01,160 --> 00:26:59,340
cap carbonates and carbonized of

560
00:27:03,470 --> 00:27:01,170
anomalies not in which is known about

561
00:27:04,670 --> 00:27:03,480
that paper up there don't but it's

562
00:27:07,040 --> 00:27:04,680
actually a model that has been

563
00:27:08,000 --> 00:27:07,050

surprisingly resilient people we've been

564
00:27:11,890 --> 00:27:08,010
shooting here but I don't think

565
00:27:16,390 --> 00:27:11,900
anybody's really fatally wounded it yet

566
00:27:19,340 --> 00:27:16,400
just in terms of time scale well

567
00:27:21,470 --> 00:27:19,350
this is a really lucky they don't have

568
00:27:23,270 --> 00:27:21,480
any really good nature the duration of

569
00:27:26,810 --> 00:27:23,280
these things I might it might say in

570
00:27:29,990 --> 00:27:26,820
South Africa we do have a rhenium osmium

571
00:27:31,700 --> 00:27:30,000
date from below the Mac in any snowball

572
00:27:32,210 --> 00:27:31,710
in about two point two three the dates

573
00:27:34,909 --> 00:27:32,220
on top

574
00:27:37,000 --> 00:27:34,919
that come out at 2.22 which leaves

575
00:27:39,980 --> 00:27:37,010
something like 80 to 100 million years

576
00:27:43,940 --> 00:27:39,990
for that particular location and that's

577
00:27:47,029 --> 00:27:43,950
not incompatible with the outgassing

578
00:27:48,799 --> 00:27:47,039
time scale that we estimated earlier and

579
00:27:49,430 --> 00:27:48,809
again you you have all these reasons

580
00:27:52,370 --> 00:27:49,440
happening

581
00:27:56,120 --> 00:27:52,380
now why was the three darts at various

582
00:27:59,000 --> 00:27:56,130
bits of this but that's fine swing

583
00:28:01,700 --> 00:27:59,010
models moved certainly in South Africa

584
00:28:03,830 --> 00:28:01,710
when we look at the aftermath of this

585
00:28:07,370 --> 00:28:03,840
collision or the glaciation is because

586
00:28:13,630 --> 00:28:07,380
we drop stones still on top of the uncle

587
00:28:20,659 --> 00:28:18,500
at least they're very locally confined

588
00:28:22,820 --> 00:28:20,669

only to the bottom half metres of a

589
00:28:25,850 --> 00:28:22,830
hotter cell formation then a few meters

590
00:28:28,310 --> 00:28:25,860
higher than that you go into this banded

591
00:28:30,680 --> 00:28:28,320
manganese unit which trades into the

592
00:28:32,470 --> 00:28:30,690
Colorado values field and it is really

593
00:28:36,020 --> 00:28:32,480
you know it's really an incredible

594
00:28:41,419 --> 00:28:36,030
deposit the oxygen link is a good one

595
00:28:42,710 --> 00:28:41,429
because you basically need molecular

596
00:28:45,409 --> 00:28:42,720
oxygen to do it you could do it with

597
00:28:46,909 --> 00:28:45,419
nitrates in the ocean electrochemically

598
00:28:50,390 --> 00:28:46,919
but do you get nitrate you need oxygen

599
00:28:55,760 --> 00:28:50,400
so that doesn't help you and the

600
00:28:57,380 --> 00:28:55,770
kalahari man is 30 kilometers long by 11

601
00:29:00,980 --> 00:28:57,390
kilometers wide with a blanket of

602
00:29:05,230 --> 00:29:00,990
manganese rich sediments but 250 meters

603
00:29:08,690 --> 00:29:05,240
thick it's actually unique deposit under

604
00:29:11,360 --> 00:29:08,700
the Japanese public television film

605
00:29:14,180 --> 00:29:11,370
under the other haka produces beautiful

606
00:29:17,560 --> 00:29:14,190
scenes there is a video basically

607
00:29:22,070 --> 00:29:17,570
described deposits that they don't mind

608
00:29:24,289 --> 00:29:22,080
this is a big deal is a concentration of

609
00:29:25,880 --> 00:29:24,299
manganese in those waste deposits is

610
00:29:28,730 --> 00:29:25,890
bigger than many other manganese mines

611
00:29:31,279 --> 00:29:28,740
in the world it's right away because

612
00:29:32,600 --> 00:29:31,289
it's not there high-grade ore of course

613
00:29:34,230 --> 00:29:32,610

I like your chemically as they said

614
00:29:35,870 --> 00:29:34,240
Dunsey on the rock

615
00:29:38,340 --> 00:29:35,880
right here with the manganese

616
00:29:39,510 --> 00:29:38,350
precipitation and the other case models

617
00:29:41,820 --> 00:29:39,520
that you would expect have been knocked

618
00:29:45,090 --> 00:29:41,830
out by Isis answers are there too so I

619
00:29:47,040 --> 00:29:45,100
hope that is the oldest really firm

620
00:29:49,620 --> 00:29:47,050
bullet proof constraint in Earth history

621
00:29:51,960 --> 00:29:49,630
for having molecular oxygen now whether

622
00:29:54,660 --> 00:29:51,970
it's photosynthetic oxygen or this weird

623
00:29:57,360 --> 00:29:54,670
snowball peroxide effect I can't say but

624
00:29:59,790 --> 00:29:57,370
in fact after this point in Earth

625
00:30:03,419 --> 00:29:59,800
history we lose the mass independent

626
00:30:05,490 --> 00:30:03,429
fractionation the sulfur isotopes argue

627
00:30:07,950 --> 00:30:05,500
that is probably coincident also with

628
00:30:16,169 --> 00:30:07,960
cyanobacterial evolution the flow system

629
00:30:18,870 --> 00:30:16,179
to this really go 79 days remain real

630
00:30:22,260 --> 00:30:18,880
maybe these sorts over in that there are

631
00:30:24,299 --> 00:30:22,270
Kidd carbonates the weather later in

632
00:30:26,490 --> 00:30:24,309
action but there's no blood parent

633
00:30:31,799 --> 00:30:26,500
younger weapon earth history where you

634
00:30:33,660 --> 00:30:31,809
have sedimentary manganese isn't the

635
00:30:36,360 --> 00:30:33,670
neoproterozoic glaciations there are red

636
00:30:38,430 --> 00:30:36,370
beds then the makuhita in the Mackenzie

637
00:30:42,030 --> 00:30:38,440
mountains the Rappahannock group as well

638
00:30:44,370 --> 00:30:42,040

as in Brazil and deposits which also

639
00:30:46,799 --> 00:30:44,380
have this high manganese Association but

640
00:30:49,020 --> 00:30:46,809
they are always associated with these

641
00:30:50,760 --> 00:30:49,030
neoproterozoic the glaciations

642
00:30:53,130 --> 00:30:50,770
so I think there's a good argument to be

643
00:30:56,610 --> 00:30:53,140
made that those glaciations are indeed

644
00:30:58,560 --> 00:30:56,620
so fiddling somehow with oxygen in the

645
00:31:14,070 --> 00:30:58,570
Earth's oceans they're in the atmosphere

646
00:31:18,290 --> 00:31:14,080
and a lot of fun there's not much

647
00:31:21,090 --> 00:31:18,300
happening it's all about 2.3 billion

648
00:31:24,060 --> 00:31:21,100
which correspond to the initial

649
00:31:25,410 --> 00:31:24,070
evolution of photosystem ii the bugs

650
00:31:27,000 --> 00:31:25,420
probably brought down that methane

651
00:31:29,310 --> 00:31:27,010
component i prog-rock

652
00:31:32,070 --> 00:31:29,320
then I published a paper in PNAS couple

653
00:31:33,990 --> 00:31:32,080
years ago where we argued that within a

654
00:31:36,740 --> 00:31:34,000
hundred thousand years or so maybe a

655
00:31:39,690 --> 00:31:36,750
million that first mutant

656
00:31:41,640 --> 00:31:39,700
cyanobacterium could conceivably wipe

657
00:31:44,130 --> 00:31:41,650
out a millibar methane atmosphere a

658
00:31:44,520 --> 00:31:44,140
millibar methane greenhouse component to

659
00:31:48,750 --> 00:31:44,530
the

660
00:31:51,600 --> 00:31:48,760
feet out of it under global climate and

661
00:31:52,920 --> 00:31:51,610
triggering going into a snowball we

662
00:31:54,660 --> 00:31:52,930
don't have many good mechanisms for

663
00:31:56,850 --> 00:31:54,670

getting injured snow along with fairly

664
00:31:58,410 --> 00:31:56,860
sure we can get out of them if you're

665
00:32:00,480 --> 00:31:58,420
climbing one will survive it getting

666
00:32:03,630 --> 00:32:00,490
into them has been a big problem kicking

667
00:32:04,860 --> 00:32:03,640
out nothing is driving Hoffman and

668
00:32:06,720 --> 00:32:04,870
others have pointed out is a good way

669
00:32:08,910 --> 00:32:06,730
but here we've got a good way for

670
00:32:12,330 --> 00:32:08,920
kicking that out but also it means that

671
00:32:14,240 --> 00:32:12,340
that single mutant cyanobacterium

672
00:32:20,280 --> 00:32:14,250
destroyed a whole planetary ecosystem

673
00:32:23,070 --> 00:32:20,290
mmm yeah nice and after that it's been

674
00:32:25,710 --> 00:32:23,080
kind of fun so there is it really have

675
00:32:28,590 --> 00:32:25,720
destroyed an entire ecosystem thanks

676
00:32:31,800 --> 00:32:28,600
I can't no nobody's really shot at

677
00:32:33,890 --> 00:32:31,810
Battin tried to dissuade us it's very

678
00:32:43,710 --> 00:32:33,900
simple exponential growth limited by

679
00:32:46,130 --> 00:32:43,720
iron phosphate well that's true Lovelock

680
00:32:50,100 --> 00:32:46,140
it's completely ignores low-latitude

681
00:32:53,550 --> 00:32:50,110
glaciation his assertion is that Gaia if

682
00:32:56,310 --> 00:32:53,560
she exists has been regulating the

683
00:32:58,550 --> 00:32:56,320
climate but I would argue that you know

684
00:33:01,380 --> 00:32:58,560
if the cyanobacterium really came in and

685
00:33:05,070 --> 00:33:01,390
damn near exterminated the biosphere

686
00:33:08,090 --> 00:33:05,080
that's not a very kind idea there's no

687
00:33:10,590 --> 00:33:08,100
way that she would know that you know

688
00:33:15,000 --> 00:33:10,600

animals could evolve because of the

689
00:33:17,250 --> 00:33:15,010
response toxin in in fact actually if

690
00:33:20,610 --> 00:33:17,260
the earth had been a little further away

691
00:33:24,270 --> 00:33:20,620
you could envision this paleoproterozoic

692
00:33:26,010 --> 00:33:24,280
snowball building up co2 ice caps if we

693
00:33:28,620 --> 00:33:26,020
got cold enough I mean you're just a

694
00:33:30,330 --> 00:33:28,630
little bit off from that maybe Stephen

695
00:33:32,970 --> 00:33:30,340
could say something about that if you

696
00:33:35,540 --> 00:33:32,980
could get it cold enough to put co2 in

697
00:33:38,760 --> 00:33:35,550
the ice caps you might have really

698
00:33:42,690 --> 00:33:38,770
inhibited this escape from snowball and

699
00:33:47,670 --> 00:33:42,700
so they got this guy I'm afraid was

700
00:33:51,480 --> 00:33:47,680
killed by a flying snowball working for

701
00:33:53,790 --> 00:33:51,490
young but there's leaves the problem

702
00:33:57,570 --> 00:33:53,800
about these other things in Earth

703
00:33:57,850 --> 00:33:57,580
history there are lot of depreciations

704
00:34:00,880 --> 00:33:57,860
and

705
00:34:04,260 --> 00:34:00,890
Razak they have weird carbon isotope

706
00:34:07,720 --> 00:34:04,270
variations crazy sea-level effects could

707
00:34:09,700 --> 00:34:07,730
we explain those things through some

708
00:34:11,409 --> 00:34:09,710
other mechanisms there is an interesting

709
00:34:13,780 --> 00:34:11,419
other mechanism that we've been working

710
00:34:16,960 --> 00:34:13,790
on in there for the caber starting with

711
00:34:19,149 --> 00:34:16,970
Cambrian explosion but elsewhere and

712
00:34:21,520 --> 00:34:19,159
that is what's called true pull and

713
00:34:23,950 --> 00:34:21,530

wonders all give a couple lines of

714
00:34:27,720 --> 00:34:23,960
introduction the true blow wonder is a

715
00:34:30,399 --> 00:34:27,730
process where the whole solid earth

716
00:34:33,340 --> 00:34:30,409
changes its orientation relative to the

717
00:34:37,240 --> 00:34:33,350
spin axis to the moment of inertia

718
00:34:40,210 --> 00:34:37,250
vector in the ideas that planets will

719
00:34:43,359 --> 00:34:40,220
spin such that their principal moment

720
00:34:45,220 --> 00:34:43,369
that the mass distributions the

721
00:34:46,990 --> 00:34:45,230
principal moment of inertia is the spin

722
00:34:49,720 --> 00:34:47,000
axis basically means if there's excess

723
00:34:51,340 --> 00:34:49,730
NASA wants to go to the crime fighter if

724
00:34:54,550 --> 00:34:51,350
there are regions with less mass that

725
00:34:56,980 --> 00:34:54,560
will go to the pole and certainly we

726
00:34:58,900 --> 00:34:56,990
know that on earth these masses can

727
00:35:02,620 --> 00:34:58,910
appear and disappear like this beetle

728
00:35:07,780 --> 00:35:02,630
that I'm manipulating he received aids

729
00:35:10,359 --> 00:35:07,790
in well we do know that cupola wander

730
00:35:12,970 --> 00:35:10,369
does happen we can see it in the moon on

731
00:35:14,620 --> 00:35:12,980
Mars and Enceladus like every play that

732
00:35:17,020 --> 00:35:14,630
we know of would you get a good gravity

733
00:35:19,180 --> 00:35:17,030
field turns out it's it's spin it around

734
00:35:21,099 --> 00:35:19,190
its principal moment of inertia it's

735
00:35:24,190 --> 00:35:21,109
basically saying that these heavy

736
00:35:25,930 --> 00:35:24,200
objects massive uncompensated massive

737
00:35:28,540 --> 00:35:25,940
numbers will tend to go towards the

738
00:35:32,020 --> 00:35:28,550

equator and there's a very good example

739
00:35:35,349 --> 00:35:32,030
on Mars the first problems here this

740
00:35:39,090 --> 00:35:35,359
good spot on we declare it has to be

741
00:35:43,420 --> 00:35:39,100
just the way they're not a planet works

742
00:35:45,280 --> 00:35:43,430
and if you were to do and what we call

743
00:35:47,890 --> 00:35:45,290
an inertial interchange event where you

744
00:35:50,950 --> 00:35:47,900
actually let the beetles crawling around

745
00:35:53,440 --> 00:35:50,960
on earth get big and small and getting

746
00:35:55,870 --> 00:35:53,450
to a stage where the principal and

747
00:35:58,300 --> 00:35:55,880
intermediate moment of inertia about the

748
00:36:03,580 --> 00:35:58,310
same you can get relatively large

749
00:36:04,980 --> 00:36:03,590
magnitudes effects and moments after

750
00:36:09,990 --> 00:36:04,990
that

751
00:36:13,500 --> 00:36:10,000
you wouldn't pick all this highlighted

752
00:36:15,600 --> 00:36:13,510
areas and move them on hold cetera

753
00:36:18,150 --> 00:36:15,610
that's what we're talking about we're

754
00:36:22,320 --> 00:36:18,160
not changing your book we we're not

755
00:36:24,210 --> 00:36:22,330
changing in the spin axis for the whole

756
00:36:26,220 --> 00:36:24,220
planet just relative to the solid

757
00:36:28,830 --> 00:36:26,230
do you still concern your momentum and

758
00:36:31,680 --> 00:36:28,840
the way to envision that is to think you

759
00:36:34,170 --> 00:36:31,690
know these processes are occurring on

760
00:36:37,530 --> 00:36:34,180
the volunteers to tens of millions your

761
00:36:40,620 --> 00:36:37,540
scale you're shifting the solid earth 90

762
00:36:44,100 --> 00:36:40,630
degrees in 10 million years maybe

763
00:36:48,240 --> 00:36:44,110

but the planet is spinning 360 degrees a

764
00:36:50,580 --> 00:36:48,250
day so the actual perturbation of the

765
00:36:52,980 --> 00:36:50,590
spin axis mega there's one part into the

766
00:36:57,870 --> 00:36:52,990
seventh so it's not a big deal

767
00:37:00,990 --> 00:36:57,880
and a planetary scale and we suggested

768
00:37:03,750 --> 00:37:01,000
that for the Cambrian explosion about

769
00:37:04,890 --> 00:37:03,760
ten years ago when we realized that you

770
00:37:08,670 --> 00:37:04,900
could go through the paleomagnetic

771
00:37:11,220 --> 00:37:08,680
database for all continents for the

772
00:37:14,970 --> 00:37:11,230
Cambrian and every continent was having

773
00:37:16,440 --> 00:37:14,980
this 90 degree swath of poles we sat

774
00:37:19,010 --> 00:37:16,450
back and looked at and said whoa wait

775
00:37:22,800 --> 00:37:19,020
where'd you take the holes for the earth

776
00:37:24,990 --> 00:37:22,810
and explained virtually 90 percent of

777
00:37:28,340 --> 00:37:25,000
the variants in that database more than

778
00:37:30,630 --> 00:37:28,350
one rotation when you can explain

779
00:37:33,180 --> 00:37:30,640
literally a hundred pillar magnetic

780
00:37:33,920 --> 00:37:33,190
observations 90% of the reddit's weather

781
00:37:37,410 --> 00:37:33,930
one motion

782
00:37:41,010 --> 00:37:37,420
hey that's simple okay so we suggested

783
00:37:43,200 --> 00:37:41,020
that for the camera and actually there's

784
00:37:44,910 --> 00:37:43,210
been no data published that your shoots

785
00:37:47,730 --> 00:37:44,920
that the dates of the Cambrian have

786
00:37:49,650 --> 00:37:47,740
shifted slightly in the interior but the

787
00:37:50,910 --> 00:37:49,660
length of time and the stratigraphic

788
00:37:52,380 --> 00:37:50,920

relationship to the pulse it's not

789
00:37:54,990 --> 00:37:52,390
really changed really

790
00:37:58,380 --> 00:37:55,000
a few years later collaborated with

791
00:38:01,320 --> 00:37:58,390
Jeremiah and John otherwise that in fact

792
00:38:02,820 --> 00:38:01,330
for all the predictions from that which

793
00:38:05,310 --> 00:38:02,830
actually were quite consistent with

794
00:38:06,270 --> 00:38:05,320
known sea-level effects in the Cambron

795
00:38:08,490 --> 00:38:06,280
everybody's heard of the soft

796
00:38:10,980 --> 00:38:08,500
transgression and few other things

797
00:38:12,870 --> 00:38:10,990
there's five kilometers of carbonates in

798
00:38:14,380 --> 00:38:12,880
the middle Cambrian light metal Cameron

799
00:38:16,269 --> 00:38:14,390
but I'm sure that

800
00:38:18,640 --> 00:38:16,279
exist elsewhere there's a big problem

801
00:38:20,620 --> 00:38:18,650
the the Baltic platform does not have

802
00:38:23,049 --> 00:38:20,630
five kilometers and it'll get me backs

803
00:38:26,740 --> 00:38:23,059
it has an original disc informative and

804
00:38:29,349 --> 00:38:26,750
it turns out if you go if you look at

805
00:38:31,539 --> 00:38:29,359
earth during the triple under that there

806
00:38:34,569 --> 00:38:31,549
are some interesting effects

807
00:38:36,309 --> 00:38:34,579
for North America moving down rapidly

808
00:38:38,829 --> 00:38:36,319
committing a fashion field you can get

809
00:38:41,589 --> 00:38:38,839
up to the dreaded meter if you're 15

810
00:38:43,269 --> 00:38:41,599
million you're never changed you can

811
00:38:48,160 --> 00:38:43,279
give it about a 200 meter at you static

812
00:38:50,589 --> 00:38:48,170
okay design uses for of course the basis

813
00:38:52,210 --> 00:38:50,599

of that effect is it's actually very

814
00:38:54,220 --> 00:38:52,220
well Mountain it's something you have to

815
00:38:56,529 --> 00:38:54,230
worry about today when you look at the

816
00:38:57,970 --> 00:38:56,539
modern sea level isotopes because in

817
00:38:59,769 --> 00:38:57,980
fact there is some true Pillai wander

818
00:39:03,819 --> 00:38:59,779
going on today the ice caps have melted

819
00:39:05,769 --> 00:39:03,829
and the spin axis is moving back towards

820
00:39:08,410 --> 00:39:05,779
the moment of inertia that's my moment

821
00:39:10,599 --> 00:39:08,420
in yours it's sort of aching we're

822
00:39:12,400 --> 00:39:10,609
talking about that there and the

823
00:39:15,579 --> 00:39:12,410
sealable effects is very simple dramatic

824
00:39:19,950 --> 00:39:15,589
because they have to spin its radius

825
00:39:23,650 --> 00:39:19,960
that the Equator is ten kilometers of

826
00:39:29,109 --> 00:39:23,660
course so it's better to waste and if

827
00:39:31,390 --> 00:39:29,119
you imagine here towards the equator the

828
00:39:33,009 --> 00:39:31,400
lithosphere has a lot of time relative

829
00:39:36,490 --> 00:39:33,019
to the ocean Yoshi is instant

830
00:39:38,769 --> 00:39:36,500
so let's relax so if you're rotating a

831
00:39:41,230 --> 00:39:38,779
triple and water on the equator it will

832
00:39:42,480 --> 00:39:41,240
be a relative sea level transgression at

833
00:39:46,079 --> 00:39:42,490
that point

834
00:39:48,339 --> 00:39:46,089
if you are on the equator moving away

835
00:39:52,420 --> 00:39:48,349
though with the series lagging the other

836
00:39:56,220 --> 00:39:52,430
way in there will be a delay so I'm

837
00:39:59,950 --> 00:39:56,230
sorry this throws a giant monkey wrench

838
00:40:03,099 --> 00:39:59,960

towards international intercontinental

839
00:40:04,660 --> 00:40:03,109
sequences to keep your feet because it's

840
00:40:05,980 --> 00:40:04,670
based on the assumption that you static

841
00:40:08,589 --> 00:40:05,990
see you have effects are global and

842
00:40:11,230 --> 00:40:08,599
synchronous during a trip you're longer

843
00:40:17,759 --> 00:40:11,240
a bit they go up and down in quadratures

844
00:40:20,829 --> 00:40:17,769
and come on let's look at it in the

845
00:40:22,420 --> 00:40:20,839
first true part this is a summary of

846
00:40:24,120 --> 00:40:22,430
carbonized steps that I just going to

847
00:40:27,780 --> 00:40:24,130
use the plot in your brothers

848
00:40:30,690 --> 00:40:27,790
time the place where we have possible a

849
00:40:33,150 --> 00:40:30,700
lot of the glaciations our Surgeon Park

850
00:40:36,510 --> 00:40:33,160
summer Nolan our mlady there's only the

851
00:40:43,230 --> 00:40:36,520
beta continuity business the Cambrian

852
00:40:45,330 --> 00:40:43,240
event that we recognized once we got

853
00:40:47,760 --> 00:40:45,340
that going you would say well you know

854
00:40:49,020 --> 00:40:47,770
again just like the snowballs when we

855
00:40:51,360 --> 00:40:49,030
had one little attitude

856
00:40:52,740 --> 00:40:51,370
let's roll event nobody's going to

857
00:40:53,930 --> 00:40:52,750
believe it in the earth science

858
00:40:56,250 --> 00:40:53,940
community unless you could find another

859
00:40:58,080 --> 00:40:56,260
that's why we went and spent all this

860
00:40:59,760 --> 00:40:58,090
time in the Paleo Proterozoic in the Mac

861
00:41:01,980 --> 00:40:59,770
community you have two separate

862
00:41:05,580 --> 00:41:01,990
intervals of Earth history the similar

863
00:41:07,020 --> 00:41:05,590

effects is more likely to be true rather

864
00:41:08,970 --> 00:41:07,030
than an artifact or somebody tells

865
00:41:13,490 --> 00:41:08,980
something about the planet the same way

866
00:41:15,720 --> 00:41:13,500
if we have a potential donor came

867
00:41:17,670 --> 00:41:15,730
presumably we might see it also and

868
00:41:19,290 --> 00:41:17,680
there are several implications of this

869
00:41:23,190 --> 00:41:19,300
that are coming up in fact this is

870
00:41:25,470 --> 00:41:23,200
entire interval 700 550 throw away all

871
00:41:27,030 --> 00:41:25,480
conventional tectonics because you're

872
00:41:29,340 --> 00:41:27,040
going to start be explaining it in terms

873
00:41:31,080 --> 00:41:29,350
of truthful and wander episodes and you

874
00:41:34,080 --> 00:41:31,090
can actually do things like reconstruct

875
00:41:36,960 --> 00:41:34,090
Gondwanaland which you know I'll go back

876
00:41:40,200 --> 00:41:36,970
to the next of it which formed a big

877
00:41:43,380 --> 00:41:40,210
part of adamant roofs PhD thesis no

878
00:41:45,510 --> 00:41:43,390
nobody was a student of Omaha flu the

879
00:41:48,270 --> 00:41:45,520
property is working like that smiler

880
00:41:50,400 --> 00:41:48,280
he's now at Princeton the bitter springs

881
00:41:53,190 --> 00:41:50,410
for far longer events there's a funny

882
00:41:55,740 --> 00:41:53,200
step function and the carbon isotopes in

883
00:41:59,700 --> 00:41:55,750
Australia in the bitter springs

884
00:42:02,070 --> 00:41:59,710
formation that Maloof has picked up also

885
00:42:04,680 --> 00:42:02,080
in Millicent move in the Gillan

886
00:42:07,880 --> 00:42:04,690
Halverson they picked up in small bars

887
00:42:12,120 --> 00:42:07,890
and basically the color magnetic summary

888
00:42:13,890 --> 00:42:12,130

suggest this hallmark is here now the

889
00:42:16,020 --> 00:42:13,900
magnetic summary suggests the pilot

890
00:42:18,360 --> 00:42:16,030
looked like this back in there doing a

891
00:42:21,210 --> 00:42:18,370
little exhibit of you and if you look

892
00:42:24,390 --> 00:42:21,220
carefully you'll see that the amount of

893
00:42:29,070 --> 00:42:24,400
land and the tropics various during this

894
00:42:30,940 --> 00:42:29,080
event and Falls often back so what we

895
00:42:32,740 --> 00:42:30,950
found is kind of interesting

896
00:42:35,349 --> 00:42:32,750
you go through the sequence in small

897
00:42:37,890 --> 00:42:35,359
part there were two or one big old Nancy

898
00:42:41,470 --> 00:42:37,900
deciding on whether it's here and there

899
00:42:44,560 --> 00:42:41,480
the carbon isotope shifts occur across

900
00:42:47,410 --> 00:42:44,570
those so this is stable platform number

901
00:42:50,980 --> 00:42:47,420
one peconics but the carbonate shifts

902
00:42:53,319 --> 00:42:50,990
like that and no bangle one way of

903
00:42:55,480 --> 00:42:53,329
shifting that is to change the amount of

904
00:42:56,890 --> 00:42:55,490
organic carbon that is being buried one

905
00:42:59,349 --> 00:42:56,900
way of doing that is to put more

906
00:43:01,270 --> 00:42:59,359
continents with rivers that are in low

907
00:43:03,970 --> 00:43:01,280
latitudes and that's exactly what this

908
00:43:06,730 --> 00:43:03,980
to apollo underman but the kicker is if

909
00:43:09,280 --> 00:43:06,740
you plot the pillar magnetic directions

910
00:43:13,810 --> 00:43:09,290
with your green here versus the carbon

911
00:43:16,510 --> 00:43:13,820
that's sixty degree shift occurs at that

912
00:43:20,200 --> 00:43:16,520
carbon interval so we got with one

913
00:43:23,530 --> 00:43:20,210

mechanism abrupt trip or wanderer to

914
00:43:24,849 --> 00:43:23,540
events do you want an excellent we can

915
00:43:28,599 --> 00:43:24,859
make the prediction for the carbon

916
00:43:33,990 --> 00:43:28,609
isotope ship and the ship and a little

917
00:43:37,720 --> 00:43:34,000
bit of erosional effects at that and

918
00:43:40,000 --> 00:43:37,730
that's not the only problem with north

919
00:43:41,710 --> 00:43:40,010
america it's gonna get a little weirder

920
00:43:44,370 --> 00:43:41,720
here there's been a long-standing

921
00:43:54,250 --> 00:43:44,380
problem with the latitude of lordship

922
00:43:56,980 --> 00:43:54,260
around 580 to 550 million years mind you

923
00:43:58,420 --> 00:43:56,990
we have the most data for Pele magnetics

924
00:44:00,910 --> 00:43:58,430
in this interval of time for Loretta

925
00:44:03,010 --> 00:44:00,920
much more than any other conic this is

926
00:44:05,670 --> 00:44:03,020
the problem it sticks its ugly head up

927
00:44:09,460 --> 00:44:05,680
and says no wait a minute

928
00:44:11,490 --> 00:44:09,470
so we've attacked that even if what were

929
00:44:13,990 --> 00:44:11,500
suggesting is that there may be

930
00:44:16,930 --> 00:44:14,000
oscillations like this cupola wander

931
00:44:20,710 --> 00:44:16,940
that we're picking up and looking at

932
00:44:22,300 --> 00:44:20,720
it's how you test that in fact there may

933
00:44:24,640 --> 00:44:22,310
have to be one of the slurring onion

934
00:44:28,240 --> 00:44:24,650
right here founder who suggested back

935
00:44:33,010 --> 00:44:28,250
about 10 years ago well well how do you

936
00:44:35,280 --> 00:44:33,020
test it turns out if you go to all of

937
00:44:37,930 --> 00:44:35,290
the continents that we have data for and

938
00:44:39,310 --> 00:44:37,940

step back and say well okay we know

939
00:44:41,890 --> 00:44:39,320
there's a lot of scattering that

940
00:44:43,360 --> 00:44:41,900
but let's assume that we don't know the

941
00:44:45,670 --> 00:44:43,370
number of the inertial interchange

942
00:44:51,280 --> 00:44:45,680
events but that the planet is spinning

943
00:44:54,340 --> 00:44:51,290
around some axis of mass anomaly if you

944
00:45:00,180 --> 00:44:54,350
do that you look at all the data they've

945
00:45:09,280 --> 00:45:03,960
surrounded the consumers we point out

946
00:45:12,190 --> 00:45:09,290
every has this weird dispersion of those

947
00:45:13,110 --> 00:45:12,200
poles along great serve arcs as if the

948
00:45:15,610 --> 00:45:13,120
earth is spinning

949
00:45:17,440 --> 00:45:15,620
tyrannically we've not sampled that in

950
00:45:19,450 --> 00:45:17,450
vain enough resolution to really resolve

951
00:45:21,640 --> 00:45:19,460
it and so this just the dance very

952
00:45:25,590 --> 00:45:21,650
strong up showing the poles around that

953
00:45:28,450 --> 00:45:25,600
these are the poles from an 800 just 550

954
00:45:31,240 --> 00:45:28,460
if you hit all these squares plenty of

955
00:45:33,490 --> 00:45:31,250
those balls and get the perpendicular to

956
00:45:33,730 --> 00:45:33,500
that plane and prepares it goes like

957
00:45:37,660 --> 00:45:33,740
that

958
00:45:39,760 --> 00:45:37,670
very not highly non-random actually you

959
00:45:49,330 --> 00:45:39,770
can do that for example all of the

960
00:45:51,610 --> 00:45:49,340
gunrunner continents plot things in both

961
00:45:53,610 --> 00:45:51,620
orientations and what you discover is

962
00:45:57,460 --> 00:45:53,620
that this pattern holds for all

963
00:46:00,610 --> 00:45:57,470

continents it's like you can then go

964
00:46:04,180 --> 00:46:00,620
back and reconstruct you're gonna wanna

965
00:46:10,090 --> 00:46:04,190
land and guess what all the poles come

966
00:46:13,720 --> 00:46:10,100
out on this rate circle ours but by and

967
00:46:16,180 --> 00:46:13,730
large they convert very same so we can

968
00:46:18,640 --> 00:46:16,190
explain something like 90% of the

969
00:46:21,540 --> 00:46:18,650
variance in all of the pillar magnetic

970
00:46:26,140 --> 00:46:21,550
data for the entire plate neoproterozoic

971
00:46:30,190 --> 00:46:26,150
was the triple I wonder about this hmm

972
00:46:33,910 --> 00:46:30,200
that's fun but then to focus on a little

973
00:46:35,710 --> 00:46:33,920
bit more about rate sometimes in getting

974
00:46:37,440 --> 00:46:35,720
back to this North America problem

975
00:46:40,480 --> 00:46:37,450
bouncing up and down like a yo-yo

976
00:46:44,800 --> 00:46:40,490
between the equator to pole we've got

977
00:46:48,820 --> 00:46:44,810
some neat new data from North America

978
00:46:50,440 --> 00:46:48,830
complex and Cecile's which you can

979
00:46:54,340 --> 00:46:50,450
actually see here from the Google image

980
00:46:55,870 --> 00:46:54,350
see the edge of tomato wandering in like

981
00:46:58,290 --> 00:46:55,880
that

982
00:46:59,710 --> 00:46:58,300
Mike Higgins whenever clever

983
00:47:01,960 --> 00:46:59,720
collaboration of the spreadsheet

984
00:47:05,610 --> 00:47:01,970
concerning this extensively this is the

985
00:47:09,010 --> 00:47:05,620
set fields gravity anomaly it's about

986
00:47:12,070 --> 00:47:09,020
100 kilometers complex it's entreated by

987
00:47:14,010 --> 00:47:12,080
a separate the secondary intrusion that

988
00:47:17,530 --> 00:47:14,020

comes in a little bit later

989
00:47:19,240 --> 00:47:17,540
mmm Higgins actually points out this is

990
00:47:22,570 --> 00:47:19,250
not that there are a lot of other

991
00:47:24,220 --> 00:47:22,580
volcanic needed in shield they did the

992
00:47:25,990 --> 00:47:24,230
same thing that he thinks are exclusive

993
00:47:28,770 --> 00:47:26,000
equivalents of this

994
00:47:33,100 --> 00:47:28,780
in fact he interprets that as the

995
00:47:36,000 --> 00:47:33,110
eruptive complex of a major clue yet and

996
00:47:38,640 --> 00:47:36,010
in other words he's interpreting it is

997
00:47:42,630 --> 00:47:38,650
one of these fasteners that comes up

998
00:47:46,510 --> 00:47:42,640
erupts in like me

999
00:47:48,610 --> 00:47:46,520
well not like the that kind cracks it's

1000
00:47:51,040 --> 00:47:48,620
not very fun basalt some things and yeah

1001
00:47:53,740 --> 00:47:51,050
the actual extent of those things isn't

1002
00:48:03,400 --> 00:47:53,750
over 3,000 kilometers so he said she

1003
00:48:05,910 --> 00:48:03,410
should field well the data to front we

1004
00:48:08,520 --> 00:48:05,920
replicated in earlier study this appeals

1005
00:48:11,140 --> 00:48:08,530
showing that there are in fact two

1006
00:48:14,470 --> 00:48:11,150
distinct components a low altitude a

1007
00:48:18,820 --> 00:48:14,480
component to clarity's and a high

1008
00:48:22,810 --> 00:48:18,830
latitude B component and we're able to

1009
00:48:29,890 --> 00:48:22,820
show very clearly that the the sensing

1010
00:48:33,430 --> 00:48:29,900
that can all study nineteen diabase

1011
00:48:34,930 --> 00:48:33,440
those things in the edge and an overhead

1012
00:48:38,020 --> 00:48:34,940
and a pirate

1013
00:48:40,180 --> 00:48:38,030

direction in this later stage intrusion

1014
00:48:41,890 --> 00:48:40,190
now the kicker is used to think that

1015
00:48:44,950 --> 00:48:41,900
intrusion was thirty million years

1016
00:48:49,270 --> 00:48:44,960
younger but Sir Harry has gone back and

1017
00:48:51,220 --> 00:48:49,280
dated them with Dan Condon and soon

1018
00:48:54,160 --> 00:48:51,230
popped up if you look at

1019
00:48:57,490 --> 00:48:54,170
the red which has the to clarity shadow

1020
00:49:00,069 --> 00:48:57,500
directions and this blue which is the

1021
00:49:05,740 --> 00:49:00,079
steep southwards down directions and

1022
00:49:08,650 --> 00:49:05,750
intermediate ones hmm it's implying some

1023
00:49:12,010 --> 00:49:08,660
like sixty degrees of emotion in less

1024
00:49:14,890 --> 00:49:12,020
than a million years granted we don't

1025
00:49:18,310 --> 00:49:14,900
know how to map the cooling ages from

1026
00:49:19,630 --> 00:49:18,320
the zircon to the lock-in dates but the

1027
00:49:21,190 --> 00:49:19,640
simple model says they're not going to

1028
00:49:24,790 --> 00:49:21,200
be out by more than a million years or

1029
00:49:28,300 --> 00:49:24,800
so that's a fairly standard calculation

1030
00:49:34,480 --> 00:49:28,310
but what it does what it predicts if we

1031
00:49:36,910 --> 00:49:34,490
are going that quickly that yeah you

1032
00:49:38,829 --> 00:49:36,920
might get up to four kilometers static

1033
00:49:41,250 --> 00:49:38,839
effects so I'm gonna show you what that

1034
00:49:53,950 --> 00:49:52,180
if you California basically you have the

1035
00:49:59,710 --> 00:49:53,960
shoreline at the edge of the continental

1036
00:50:03,970 --> 00:49:59,720
plane if you then walk it up gently the

1037
00:50:09,640 --> 00:50:03,980
level and then raise it you basically do

1038
00:50:12,730 --> 00:50:09,650

that now question is there anything and

1039
00:50:15,970 --> 00:50:12,740
he'd hit in the geological record that

1040
00:50:21,220 --> 00:50:15,980
something about the age of this isotope

1041
00:50:25,150 --> 00:50:21,230
of the seals intrusion 564 SH might

1042
00:50:27,130 --> 00:50:25,160
actually have done that answer yes if

1043
00:50:29,170 --> 00:50:27,140
you go to the neoproterozoic sequence

1044
00:50:32,140 --> 00:50:29,180
and the a key deeakron sequence in the

1045
00:50:38,700 --> 00:50:32,150
flenders is this funky thing called the

1046
00:50:46,270 --> 00:50:42,400
Williams and gostin have mapped out a

1047
00:50:48,910 --> 00:50:46,280
can add a channel incision there in this

1048
00:50:50,620 --> 00:50:48,920
new program is a sequence which cuts

1049
00:50:55,810 --> 00:50:50,630
down on the order of one and a half

1050
00:51:00,850 --> 00:50:58,900
a couple other basins my colleague Brian

1051
00:51:02,860 --> 00:51:00,860
Warneke thinks he's found it in the

1052
00:51:07,690 --> 00:51:02,870
Johnny information at the same interval

1053
00:51:10,840 --> 00:51:07,700
only 500 meters there but yeah so big

1054
00:51:14,020 --> 00:51:10,850
and in the hypotheses william and

1055
00:51:17,470 --> 00:51:14,030
william's in boston suggested it might

1056
00:51:20,140 --> 00:51:17,480
be a plume head uplift and they pointed

1057
00:51:22,210 --> 00:51:20,150
to this calculator currently english

1058
00:51:25,120 --> 00:51:22,220
problems but that's been read aidid and

1059
00:51:28,330 --> 00:51:25,130
it's actually much younger it's but 511

1060
00:51:30,550 --> 00:51:28,340
or the early middle Cameron moment Nick

1061
00:51:33,040 --> 00:51:30,560
Christie blicket Lamont wanted a Miss in

1062
00:51:38,320 --> 00:51:33,050
Ian Styles Robin thousands of problems

1063
00:51:41,350 --> 00:51:38,330

with that to not only there's no back

1064
00:51:43,060 --> 00:51:41,360
right left and if you were going to have

1065
00:51:46,150 --> 00:51:43,070
a drought enough to draw down the base

1066
00:51:48,760 --> 00:51:46,160
of my up your car canyons on it and what

1067
00:51:51,550 --> 00:51:48,770
we're suggesting is maybe it is these

1068
00:51:54,220 --> 00:51:51,560
the chills trooper wonder of it and in

1069
00:51:57,610 --> 00:51:54,230
fact Australia's not in the position

1070
00:51:59,970 --> 00:51:57,620
that would preclude that and in fact at

1071
00:52:02,320 --> 00:51:59,980
the same time there is a rather a sharp

1072
00:52:06,540 --> 00:52:02,330
carbon isotope anomaly this is called

1073
00:52:11,560 --> 00:52:06,550
the Shama anomalies was picked up in a

1074
00:52:13,600 --> 00:52:11,570
mine it's a car park you know drop it

1075
00:52:27,400 --> 00:52:13,610
was the trying to David the gates are

1076
00:52:29,740 --> 00:52:27,410
consistent with the 568 m at tim has Kim

1077
00:52:31,720 --> 00:52:29,750
Robins model that very carefully and you

1078
00:52:34,060 --> 00:52:31,730
don't need much

1079
00:52:36,370 --> 00:52:34,070
weathering to remineralize organic

1080
00:52:39,430 --> 00:52:36,380
matter to do that we there number ways

1081
00:52:41,620 --> 00:52:39,440
of doing it so what we think that that

1082
00:52:43,390 --> 00:52:41,630
might actually be the Joe chemical

1083
00:52:46,390 --> 00:52:43,400
fingerprint of this appeals triple or

1084
00:52:50,800 --> 00:52:46,400
wondering it and just to kind of leave

1085
00:52:53,170 --> 00:52:50,810
you all spinning and you say well maybe

1086
00:52:54,880 --> 00:52:53,180
okay we've got it Cambrian we got maybe

1087
00:52:58,270 --> 00:52:54,890
five or six events in the neoproterozoic

1088
00:53:00,340 --> 00:52:58,280

spinning and how you count a win you

1089
00:53:01,690 --> 00:53:00,350
know when did you stop

1090
00:53:04,510 --> 00:53:01,700
is there any evidence for younger

1091
00:53:07,180 --> 00:53:04,520
trooper longer and let it creep up on to

1092
00:53:09,670 --> 00:53:07,190
us in

1093
00:53:12,390 --> 00:53:09,680
times you love and know like the

1094
00:53:15,040 --> 00:53:12,400
Cretaceous actually there is a debate

1095
00:53:17,530 --> 00:53:15,050
that's been raging in the geophysical

1096
00:53:19,930 --> 00:53:17,540
literature for almost 20 years about

1097
00:53:23,680 --> 00:53:19,940
whether there are some blips of true

1098
00:53:26,680 --> 00:53:23,690
polar wander in the Cretaceous and this

1099
00:53:29,770 --> 00:53:26,690
came to a head and about seven years ago

1100
00:53:31,809 --> 00:53:29,780
when Bill say here in Harper's publish

1101
00:53:33,970 --> 00:53:31,819
this think thing in science about triple

1102
00:53:36,220 --> 00:53:33,980
and wandering and predation from sea

1103
00:53:39,400 --> 00:53:36,230
mounts in the work they said it's a

1104
00:53:47,140 --> 00:53:39,410
thing but pole position for 1981 there

1105
00:53:48,460 --> 00:53:47,150
was a shift they had proper start to see

1106
00:53:50,589 --> 00:53:48,470
months that they thought were about the

1107
00:53:53,440 --> 00:53:50,599
same age from vegetables it so that

1108
00:53:58,030 --> 00:53:53,450
but you know they were pounced

1109
00:54:00,220 --> 00:53:58,040
upon by John Purdue no and cultural with

1110
00:54:11,349 --> 00:54:00,230
the discussion of the reply and the

1111
00:54:14,079 --> 00:54:11,359
states actually how do you know did not

1112
00:54:17,319 --> 00:54:14,089
look at the other data very well because

1113
00:54:27,370 --> 00:54:17,329

I'll go through and show you just the

1114
00:54:30,120 --> 00:54:27,380
Pacific and they noted in their 1978

1115
00:54:34,990 --> 00:54:30,130
paper that he had a peculiar reversal

1116
00:54:38,620 --> 00:54:35,000
the one 3433 transition had an

1117
00:54:45,370 --> 00:54:38,630
inclination ship they did not understand

1118
00:54:48,520 --> 00:54:45,380
it hmm well I don't think about it if if

1119
00:54:51,569 --> 00:54:48,530
me was 25 degrees north latitude and you

1120
00:54:54,010 --> 00:54:51,579
have a 45-degree trooper wandered jerk

1121
00:54:56,470 --> 00:54:54,020
you get a negative inclination because

1122
00:54:59,500 --> 00:54:56,480
you're down minus 20 degrees latitude so

1123
00:55:01,059 --> 00:54:59,510
you could explain that football under it

1124
00:55:03,010 --> 00:55:01,069
wasn't just it was more that goobie

1125
00:55:04,599 --> 00:55:03,020
Omarion there's one other place in the

1126
00:55:11,340 --> 00:55:04,609
area where they still have this root

1127
00:55:13,770 --> 00:55:11,350
problem so we went with a

1128
00:55:16,860 --> 00:55:13,780
yeah Ross Mitchell he wanted to do a

1129
00:55:19,290 --> 00:55:16,870
master's thesis on this Peter were

1130
00:55:21,750 --> 00:55:19,300
denied convince them not to do the

1131
00:55:24,990 --> 00:55:21,760
Sierras to go and look at the cretaceous

1132
00:55:28,070 --> 00:55:25,000
interior seaway he's never been sampled

1133
00:55:33,630 --> 00:55:28,080
at that time interval for magnetics and

1134
00:55:35,790 --> 00:55:33,640
what would be hole beautifully arrived

1135
00:55:37,890 --> 00:55:35,800
in attic ammonites Peter not loving

1136
00:55:40,110 --> 00:55:37,900
biggest Walter M nights Peter loves

1137
00:55:42,510 --> 00:55:40,120
ammonites I love them because they're

1138
00:55:44,490 --> 00:55:42,520

not remag enticed usually and when

1139
00:55:46,620 --> 00:55:44,500
behold when you plot the magnetic

1140
00:55:50,370 --> 00:55:46,630
directions from the sampling sites there

1141
00:55:53,310 --> 00:55:50,380
what we got was in a spring they will be

1142
00:55:57,750 --> 00:55:53,320
go along the same lines of the North

1143
00:55:59,370 --> 00:55:57,760
American Pacific plate and you know if

1144
00:56:01,860 --> 00:55:59,380
you go back to our mu oh wait a minute

1145
00:56:04,170 --> 00:56:01,870
let's look at the chrome 33 our

1146
00:56:09,840 --> 00:56:04,180
directions where we've got good data

1147
00:56:15,060 --> 00:56:09,850
everywhere basin not mix it up all of

1148
00:56:17,400 --> 00:56:15,070
these things English truck with Paul

1149
00:56:21,330 --> 00:56:17,410
McHenry sees this we dive into it pull

1150
00:56:23,520 --> 00:56:21,340
out his view GPS from crime 33 and guess

1151
00:56:26,790 --> 00:56:23,530
what they follow the same dispersion as

1152
00:56:28,500 --> 00:56:26,800
these so in fact as far as you can see

1153
00:56:30,630 --> 00:56:28,510
all of the data

1154
00:56:38,700 --> 00:56:30,640
Global databases with high-resolution

1155
00:56:41,880 --> 00:56:38,710
sampling they're all goodness and if I

1156
00:56:44,580 --> 00:56:41,890
could throw them all together and these

1157
00:56:46,590 --> 00:56:44,590
are all the inertial minimum axis

1158
00:56:48,990 --> 00:56:46,600
assistant for honor is where that's all

1159
00:56:52,260 --> 00:56:49,000
going and there's actually something

1160
00:56:55,230 --> 00:56:52,270
very intriguing if you look at where

1161
00:56:58,700 --> 00:56:55,240
India was back then and where the Deccan

1162
00:57:02,400 --> 00:56:58,710
Traps eruptive site was going to come up

1163
00:57:06,150 --> 00:57:02,410

its life on that axis perpendicular to

1164
00:57:10,280 --> 00:57:06,160
that rotation axis if so the interesting

1165
00:57:15,390 --> 00:57:10,290
possibility this dispersion is about 80

1166
00:57:17,599 --> 00:57:15,400
to 81 million years ago numerical models

1167
00:57:19,519 --> 00:57:17,609
of how long it takes is blue

1168
00:57:22,370 --> 00:57:19,529
through from say the core-mantle

1169
00:57:26,089 --> 00:57:22,380
boundary up to where it is on the quest

1170
00:57:29,920 --> 00:57:26,099
ten to fifteen million years you go ten

1171
00:57:33,019 --> 00:57:29,930
to fifteen million years after that

1172
00:57:39,049 --> 00:57:33,029
crime 33 our end you get to the KT

1173
00:57:40,249 --> 00:57:39,059
boundary roughly but this is the

1174
00:57:47,410 --> 00:57:40,259
core-mantle boundary whatever is

1175
00:57:53,930 --> 00:57:51,440
it would also maybe explain why you went

1176
00:57:56,720 --> 00:57:53,940
from a magnetic field which was stable

1177
00:57:58,789 --> 00:57:56,730
with no reversals to the point where you

1178
00:58:01,640 --> 00:57:58,799
had many many reversals probably too low

1179
00:58:06,849 --> 00:58:01,650
you need to do something to tickle the

1180
00:58:15,380 --> 00:58:11,690
it's a good one so finally to conclude I

1181
00:58:18,259 --> 00:58:15,390
say from studying the Precambrian we've

1182
00:58:19,999 --> 00:58:18,269
got a couple lessons for understanding

1183
00:58:24,370 --> 00:58:20,009
and the resort climates that are kind of

1184
00:58:27,049 --> 00:58:24,380
neat first Eris is capable of climatic

1185
00:58:28,549 --> 00:58:27,059
excursions that are really far larger

1186
00:58:31,009 --> 00:58:28,559
than we've seen in the last billion

1187
00:58:33,950 --> 00:58:31,019
years and one of them might have a

1188
00:58:36,799 --> 00:58:33,960

biological origin the second way is

1189
00:58:39,259 --> 00:58:36,809
event earth is a dynamic planet it can

1190
00:58:41,839 --> 00:58:39,269
be tumbled by large-scale tectonic

1191
00:58:43,970 --> 00:58:41,849
processes like mantle plumes and if

1192
00:58:46,700 --> 00:58:43,980
you're going to be relying on sea-level

1193
00:58:49,249 --> 00:58:46,710
correlations of that sort then carbon

1194
00:58:50,660 --> 00:58:49,259
isotope shifts might want to know if

1195
00:58:52,700 --> 00:58:50,670
these things are happening at the time

1196
00:59:12,160 --> 00:58:52,710
that are we doing it well thank you very

1197
00:59:23,120 --> 00:59:15,800
you know what those deposits

1198
00:59:25,190 --> 00:59:23,130
well actually the seals event we think

1199
00:59:27,859 --> 00:59:25,200
we know roughly where it is that if it's

1200
00:59:29,330 --> 00:59:27,869
the Strom isotope excursion we think we

1201
00:59:32,380 --> 00:59:29,340
know roughly where that is it's in the

1202
00:59:35,480 --> 00:59:32,390
rainstorm member of the Johnny formation

1203
00:59:37,130 --> 00:59:35,490
there are erosion channels and in fills

1204
00:59:38,420 --> 00:59:37,140
that have been seams you can see it in

1205
00:59:39,700 --> 00:59:38,430
the southern end of the millpond range

1206
00:59:42,440 --> 00:59:39,710
it worth it

1207
00:59:45,350 --> 00:59:42,450
come in the eruption those Hamelin bits

1208
00:59:47,030 --> 00:59:45,360
and pieces get thrown back dan jeez yeah

1209
01:00:06,800 --> 00:59:47,040
we may be able to put your finger on

1210
01:00:09,530 --> 01:00:06,810
that only happens if there is a lack of

1211
01:00:11,240 --> 01:00:09,540
oxygen and those on the screen in the

1212
01:00:13,430 --> 01:00:11,250
atmosphere you need that hard

1213
01:00:16,640 --> 01:00:13,440

ultraviolet you hit the ice cap before

1214
01:00:18,890 --> 01:00:16,650
you can do it and presumably the ozone

1215
01:00:21,320 --> 01:00:18,900
hole in Antartica central for genic of

1216
01:00:23,240 --> 01:00:21,330
some sort it would be fun to go back and

1217
01:00:24,710 --> 01:00:23,250
do more high-resolution records to see

1218
01:00:26,870 --> 01:00:24,720
if that's true or not my bill TV

1219
01:00:30,500 --> 01:00:26,880
detective but certainly the sternal

1220
01:00:32,720 --> 01:00:30,510
paper shows that hair loss with depth in

1221
01:00:34,250 --> 01:00:32,730
the ice which is not inconsistent with

1222
01:00:38,560 --> 01:00:34,260
what we think we know about the

1223
01:00:43,700 --> 01:00:38,570
atmosphere in this is quite for parties

1224
01:00:49,670 --> 01:00:45,920
why do you exclude or at least burn

1225
01:00:55,760 --> 01:00:49,680
exclude perspiration of option bicycle

1226
01:00:57,410 --> 01:00:55,770
Telesis of water vapor yeah that process

1227
01:00:59,930 --> 01:00:57,420
was presumably what's happening at the

1228
01:01:01,549 --> 01:00:59,940
top of the ice sheet problem is the

1229
01:01:05,930 --> 01:01:01,559
oxygen doesn't hang around very long

1230
01:01:08,030 --> 01:01:05,940
in fact reacts with ultraviolet while

1231
01:01:10,040 --> 01:01:08,040
verify an answer yeah but that's not

1232
01:01:12,470 --> 01:01:10,050
where life lives the point is you I want

1233
01:01:18,890 --> 01:01:12,480
something to drive the fog covers and

1234
01:01:22,220 --> 01:01:18,900
escapes but the oxygen is quickly wiped

1235
01:01:23,720 --> 01:01:22,230
out by other gases we have we know that

1236
01:01:26,510 --> 01:01:23,730
the atmosphere we think we know the

1237
01:01:29,920 --> 01:01:26,520
atmosphere was anaerobic because of the

1238
01:01:32,809 --> 01:01:29,930

mass independent so frost data was

1239
01:01:35,510 --> 01:01:32,819
arguments that we had you know very low

1240
01:01:36,740 --> 01:01:35,520
po2 in the atmosphere so whatever's

1241
01:01:39,109 --> 01:01:36,750
happening the oxygen produced

1242
01:01:39,920 --> 01:01:39,119
automatically it's not getting down to

1243
01:01:42,920 --> 01:01:39,930
the Basra

1244
01:01:44,990 --> 01:01:42,930
the problem has been how to separate the

1245
01:01:47,390 --> 01:01:45,000
brats edge that you generate by this

1246
01:01:48,950 --> 01:01:47,400
photochemical process and get it to a

1247
01:02:14,240 --> 01:01:48,960
place where we can have a biological

1248
01:02:16,940 --> 01:02:14,250
effect if you will right into a new mass

1249
01:02:24,140 --> 01:02:16,950
distribution within the earth a very

1250
01:02:27,349 --> 01:02:24,150
rapid change out I mean because if we

1251
01:02:29,990 --> 01:02:27,359
knew the mechanism we might be able to

1252
01:02:31,730 --> 01:02:30,000
answer that question I can conceive of a

1253
01:02:34,130 --> 01:02:31,740
way where you can get a little Burpee

1254
01:02:38,960 --> 01:02:34,140
blue word goes this way back again if

1255
01:02:41,420 --> 01:02:38,970
you assume you're getting rid of in the

1256
01:02:47,150 --> 01:02:41,430
Cretaceous one normal lasted about 45 to

1257
01:02:47,809 --> 01:02:47,160
50 million years if it's if the reversal

1258
01:02:49,730 --> 01:02:47,819
right Lydia

1259
01:02:53,270 --> 01:02:49,740
if the reversal right was cut down

1260
01:02:53,809 --> 01:02:53,280
because some geometry of the D double

1261
01:02:55,880 --> 01:02:53,819
Prime

1262
01:02:58,130 --> 01:02:55,890
core mantle boundary was insulating it

1263
01:03:01,579 --> 01:02:58,140

not what it heat out you could envision

1264
01:03:05,150 --> 01:03:01,589
the heat you know the whatever sources

1265
01:03:07,309 --> 01:03:05,160
the heat becoming unstable punching

1266
01:03:10,009 --> 01:03:07,319
through d double prime separating it

1267
01:03:13,039 --> 01:03:10,019
aside which case you would have hat less

1268
01:03:15,109 --> 01:03:13,049
dense material laterally displacing

1269
01:03:16,569 --> 01:03:15,119
whatever dense material is in the double

1270
01:03:18,709 --> 01:03:16,579
prime infinity could tell me from this

1271
01:03:23,209 --> 01:03:18,719
that would hit that rocket towards the

1272
01:03:27,199 --> 01:03:23,219
equator as it came out and escaped that

1273
01:03:30,049 --> 01:03:27,209
get up with climb layer would reform in

1274
01:03:32,029 --> 01:03:30,059
do the other way so I can envision a

1275
01:04:01,069 --> 01:03:32,039
process where you really give it

1276
01:04:08,959 --> 01:04:01,079
parenting despite can be on coming at

1277
01:04:16,009 --> 01:04:08,969
some point used by where it's you know

1278
01:04:19,069 --> 01:04:16,019
made your point mom you can do so maybe

1279
01:04:21,979 --> 01:04:19,079
more than one process riders but what it

1280
01:04:23,719 --> 01:04:21,989
is telling us just have to there's an

1281
01:04:27,140 --> 01:04:23,729
extended period of time from about a

1282
01:04:32,559 --> 01:04:27,150
hundred years maybe through are the

1283
01:04:34,339 --> 01:04:32,569
variability or whether it's principally

1284
01:04:36,319 --> 01:04:34,349
eigenvectors of the moment of inertia

1285
01:04:44,479 --> 01:04:36,329
were not the same please pardon the

1286
01:04:46,130 --> 01:04:44,489
internet your what what where the

1287
01:04:51,279 --> 01:04:46,140
conference will be terminated

1288
01:04:56,900 --> 01:04:51,289

know how that NASA's ongoing

1289
01:04:58,729 --> 01:04:56,910
distribution varies of time you have

1290
01:05:00,640 --> 01:04:58,739
activated the participant help menu

1291
01:05:03,470 --> 01:05:00,650
press star zero for technical assistance

1292
01:05:05,960 --> 01:05:03,480
star one to reinitiate this help menu

1293
01:05:08,420 --> 01:05:05,970
star three for private roll call star

1294
01:05:25,099 --> 01:05:08,430
six for self mute unmute or touch any

1295
01:05:27,470 --> 01:05:25,109
key to return to the conference that was

1296
01:05:30,769 --> 01:05:27,480
presumably the yearly hold on let me

1297
01:05:46,700 --> 01:05:30,779
just early yeah that's not my work

1298
01:05:53,210 --> 01:05:46,710
that's see that's a double slide so she

1299
01:05:58,519 --> 01:05:53,220
actually look at the way she's

1300
01:06:01,039 --> 01:05:58,529
increasing they go right but even the

1301
01:06:03,739 --> 01:06:01,049
high-resolution one right through there

1302
01:06:06,319 --> 01:06:03,749
Stuart's thing and it presumably there's

1303
01:06:08,779 --> 01:06:06,329
annual cycles but there's some

1304
01:06:10,009 --> 01:06:08,789
longer-term placement that's not my day

1305
01:06:15,289 --> 01:06:10,019
that we're just using it as an example

1306
01:06:17,900 --> 01:06:15,299
that chemistry that Daniel Lanois got in

1307
01:06:21,650 --> 01:06:17,910
this thesis talk to you apply to any ice