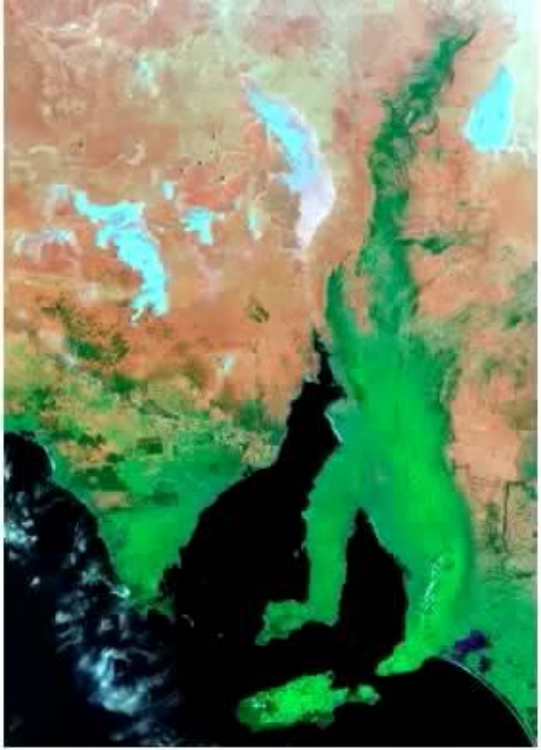

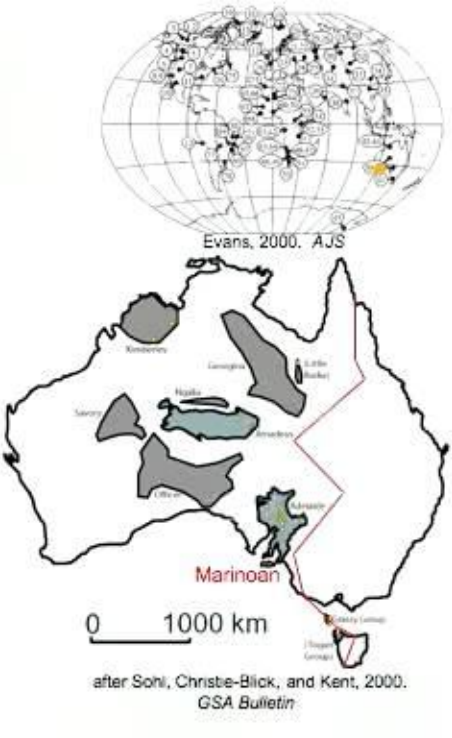

South Australia's Adelaide Depocenter and modern Flinders Ranges

1
00:00:10,100 --> 00:00:05,599
well good morning or afternoon everyone

2
00:00:13,759 --> 00:00:10,110
as the case may be thank you for joining

3
00:00:17,560 --> 00:00:13,769
us for this month's director seminar the

4
00:00:21,230 --> 00:00:17,570
topic for today's seminar sort of a rose

5
00:00:25,130 --> 00:00:21,240
as a result of a recent publication by

6
00:00:30,290 --> 00:00:25,140
members of a couple of nai teams both

7
00:00:33,139 --> 00:00:30,300
the kennel sins alumni team and Vicky

8
00:00:36,020 --> 00:00:33,149
Meadows alumni team on work done on

9
00:00:37,760 --> 00:00:36,030
snowball earth and particularly on the

10
00:00:38,959 --> 00:00:37,770
role that snowball earth may have played

11
00:00:42,410 --> 00:00:38,969
in the development of oxygen and

12
00:00:45,470 --> 00:00:42,420
photosynthesis and in talking about this

13
00:00:48,709 --> 00:00:45,480

we thought that having perhaps an even

14
00:00:52,340 --> 00:00:48,719
broader talk about the new and emerging

15
00:00:55,939 --> 00:00:52,350
perspectives on snowball earth would be

16
00:00:58,910 --> 00:00:55,949
a an interesting topic and fortunately

17
00:01:00,830 --> 00:00:58,920
we have somebody who's been spending a

18
00:01:05,750 --> 00:01:00,840
great deal of time doing that kind of

19
00:01:08,960 --> 00:01:05,760
work to present this to us Tim rob

20
00:01:12,050 --> 00:01:08,970
worked as both an undergraduate and

21
00:01:16,190 --> 00:01:12,060
master's candidate at Caltech with Joker

22
00:01:18,440 --> 00:01:16,200
shrink on snowball earth topics and has

23
00:01:20,929 --> 00:01:18,450
continued to do so I might note

24
00:01:24,890 --> 00:01:20,939
ironically that snowball earth is one of

25
00:01:28,940 --> 00:01:24,900
the hot topics in astrobiology tim is

26
00:01:31,069 --> 00:01:28,950
now finishing his PhD at Yale studying

27
00:01:36,080 --> 00:01:31,079
Earth's history and paleo magnetism of

28
00:01:38,149 --> 00:01:36,090
the EDF Aaron period and he is going to

29
00:01:39,920 --> 00:01:38,159
be talking with us about new and

30
00:01:43,039 --> 00:01:39,930
emerging perspectives on late

31
00:01:47,240 --> 00:01:43,049
precambrian snowball earth glaciation so

32
00:01:49,480 --> 00:01:47,250
Tim I will turn it over to you thanks

33
00:01:56,710 --> 00:01:52,160
central to the idea I think many

34
00:01:59,180 --> 00:01:56,720
astrobiologists is that perfectly normal

35
00:02:01,790 --> 00:01:59,190
uniformitarian geological processes

36
00:02:05,450 --> 00:02:01,800
Earth's system processes can produce

37
00:02:07,490 --> 00:02:05,460
seemingly non uniformitarian outcomes on

38
00:02:09,609 --> 00:02:07,500

a world where boundary conditions are

39
00:02:13,580 --> 00:02:09,619
sufficiently different from those today

40
00:02:15,830 --> 00:02:13,590
so keeping that idea in mind I want to

41
00:02:17,980 --> 00:02:15,840
talk about I want to review several

42
00:02:20,630 --> 00:02:17,990
recently published an ongoing studies

43
00:02:23,449 --> 00:02:20,640
probing links between Earth's deep geo

44
00:02:25,880 --> 00:02:23,459
dynamics its surface rock and ocean

45
00:02:28,070 --> 00:02:25,890
geochemical record and its atmospheric

46
00:02:33,350 --> 00:02:28,080
chemistry especially through precambrian

47
00:02:35,000 --> 00:02:33,360
time in light of its glacial record the

48
00:02:38,720 --> 00:02:35,010
classic idea that snowball earth is

49
00:02:43,460 --> 00:02:38,730
familiar to all of us in which if a

50
00:02:46,480 --> 00:02:43,470
mysterious forcing mechanism lowers the

51
00:02:49,160 --> 00:02:46,490
greenhouse effect presumably by

52
00:02:51,260 --> 00:02:49,170
decreasing either the effect or the

53
00:02:54,620 --> 00:02:51,270
concentration of greenhouse gases such

54
00:02:57,020 --> 00:02:54,630
as carbon dioxide and ice encroaches on

55
00:02:59,570 --> 00:02:57,030
the oceans to some threshold latitude at

56
00:03:02,509 --> 00:02:59,580
some point it will run away here in a

57
00:03:06,440 --> 00:03:02,519
classic one dimensional energy balance

58
00:03:09,350 --> 00:03:06,450
model leading to a snowball earth total

59
00:03:12,110 --> 00:03:09,360
ice cover scenario the greenhouse

60
00:03:15,650 --> 00:03:12,120
returned above the ice-covered oceans

61
00:03:18,620 --> 00:03:15,660
will eventually overcome the albedo

62
00:03:20,750 --> 00:03:18,630
cooling effect and the catastrophic

63
00:03:23,870 --> 00:03:20,760

return to the ice free state is presumed

64
00:03:26,330 --> 00:03:23,880
to be quick and dramatic for more

65
00:03:28,340 --> 00:03:26,340
sophisticated models rapier embarr and

66
00:03:32,390 --> 00:03:28,350
colleagues in chicago have been among

67
00:03:34,400 --> 00:03:32,400
many GCM modelers who are concerned the

68
00:03:36,110 --> 00:03:34,410
problem recently and introducing ever

69
00:03:38,630 --> 00:03:36,120
more sophisticated ice dynamic

70
00:03:41,690 --> 00:03:38,640
considerations tends to make it both

71
00:03:44,120 --> 00:03:41,700
easier to enter a hard a total snowball

72
00:03:47,990 --> 00:03:44,130
earth and also possibly harder to leave

73
00:03:51,470 --> 00:03:48,000
it but anyway so the idea is is familiar

74
00:03:53,690 --> 00:03:51,480
to many of us and exists for purposes of

75
00:03:55,850 --> 00:03:53,700
this talk and no more sophisticated a

76
00:03:58,970 --> 00:03:55,860
sense than the classical one dimensional

77
00:04:01,160 --> 00:03:58,980
energy balance model what I want to

78
00:04:01,760 --> 00:04:01,170
examine is the idea of snowball earth

79
00:04:06,170 --> 00:04:01,770
and

80
00:04:09,110 --> 00:04:06,180
is one of three possibilities either the

81
00:04:10,730 --> 00:04:09,120
very same glacial process that we see in

82
00:04:13,100 --> 00:04:10,740
the PI replace the scene record the

83
00:04:15,590 --> 00:04:13,110
Permian record the Ordovician glacial

84
00:04:17,750 --> 00:04:15,600
record but on a world with different

85
00:04:22,130 --> 00:04:17,760
boundary conditions as an entirely

86
00:04:25,160 --> 00:04:22,140
distinct glacial climate mode responsive

87
00:04:28,400 --> 00:04:25,170
the earth system some unknown forcing or

88
00:04:30,620 --> 00:04:28,410

as a continuum as boundary conditions

89
00:04:32,480 --> 00:04:30,630
change there's a whole range from hard

90
00:04:35,780 --> 00:04:32,490
snowballs in the very early precambrian

91
00:04:38,510 --> 00:04:35,790
to modern glaciations and we simply see

92
00:04:40,760 --> 00:04:38,520
a very broad gradual response or its

93
00:04:43,610 --> 00:04:40,770
climate system through time david evans

94
00:04:45,380 --> 00:04:43,620
formulated this view by telling up all

95
00:04:47,450 --> 00:04:45,390
the pay to latitude estimates either

96
00:04:50,900 --> 00:04:47,460
derived directly from the sedimentary

97
00:04:54,170 --> 00:04:50,910
record as for the Cenozoic glacial

98
00:04:57,220 --> 00:04:54,180
record here through the lens of

99
00:05:01,700 --> 00:04:57,230
paleomagnetism for the Paleozoic

100
00:05:03,320 --> 00:05:01,710
glaciations where two different extents

101
00:05:05,420 --> 00:05:03,330
we have confidence and Paley geographic

102
00:05:07,820 --> 00:05:05,430
reconstructions and through the Paley

103
00:05:09,590 --> 00:05:07,830
magnetic record of a rather limited data

104
00:05:11,990 --> 00:05:09,600
set for the neoproterozoic and

105
00:05:14,420 --> 00:05:12,000
paleoproterozoic glaciations were at

106
00:05:17,780 --> 00:05:14,430
least two highly robust paleo magnetic

107
00:05:20,090 --> 00:05:17,790
signals indicated low paler latitude for

108
00:05:22,040 --> 00:05:20,100
glacial deposits and a complete absence

109
00:05:24,170 --> 00:05:22,050
of hype a little attitude in the

110
00:05:27,190 --> 00:05:24,180
Precambrian time as opposed to just the

111
00:05:29,300 --> 00:05:27,200
opposite situation for the phanerozoic

112
00:05:32,120 --> 00:05:29,310
another way of looking at this and

113
00:05:33,890 --> 00:05:32,130

framing what I said in terms of our span

114
00:05:36,860 --> 00:05:33,900
of possible ways of looking at pre

115
00:05:40,190 --> 00:05:36,870
Cameron glaciation is this time space

116
00:05:42,940 --> 00:05:40,200
plot and I'm trying to superimpose three

117
00:05:45,920 --> 00:05:42,950
different things here one is the

118
00:05:48,190 --> 00:05:45,930
Continental configuration the paley

119
00:05:51,820 --> 00:05:48,200
Geographic style so what I've done is

120
00:05:53,330 --> 00:05:51,830
estimated in yellow the surface area of

121
00:05:55,310 --> 00:05:53,340
supercontinents that leaves the

122
00:05:57,320 --> 00:05:55,320
supercontinents that I think most

123
00:05:59,570 --> 00:05:57,330
precambrian geologists would say have a

124
00:06:03,200 --> 00:05:59,580
good chance of having existed for at

125
00:06:05,659 --> 00:06:03,210
minimum the duration in jion's indicated

126
00:06:08,300 --> 00:06:05,669
on the x axis and then taking the square

127
00:06:10,210 --> 00:06:08,310
root in kilometers of that surface area

128
00:06:12,410 --> 00:06:10,220
for each supercontinent counter land

129
00:06:15,560 --> 00:06:12,420
oldest nuna road

130
00:06:18,670 --> 00:06:15,570
Gondwanaland pangea converted the square

131
00:06:20,870 --> 00:06:18,680
root distance scale to a degree

132
00:06:22,690 --> 00:06:20,880
characteristic length scale centered on

133
00:06:25,160 --> 00:06:22,700
the equator so that taller

134
00:06:28,970 --> 00:06:25,170
supercontinents are essentially larger

135
00:06:31,610 --> 00:06:28,980
supercontinents and we also see rough

136
00:06:34,030 --> 00:06:31,620
estimates of the time intervals over

137
00:06:36,860 --> 00:06:34,040
which super content amalgamation &

138
00:06:39,110 --> 00:06:36,870

orogenesis dominated in blue leading

139
00:06:41,300 --> 00:06:39,120
into supercontinents and super

140
00:06:44,660 --> 00:06:41,310
continental drift and dispersal dragon

141
00:06:48,590 --> 00:06:44,670
you define it jian could you defend jian

142
00:06:51,350 --> 00:06:48,600
please yeah yeah jian is a convenient

143
00:06:53,950 --> 00:06:51,360
word that we can use to talk about a

144
00:06:57,170 --> 00:06:53,960
given 100 million years of Earth history

145
00:06:58,850 --> 00:06:57,180
it's simpler than a precambrian

146
00:07:02,840 --> 00:06:58,860
specialist being able to throw around

147
00:07:05,720 --> 00:07:02,850
dates like 23 16 plus or minus seven we

148
00:07:08,360 --> 00:07:05,730
can talk about jian five events and we

149
00:07:11,180 --> 00:07:08,370
mean anything from 500 million years 2

150
00:07:14,510 --> 00:07:11,190
599 million years so here the

151
00:07:16,580 --> 00:07:14,520
phanerozoic gee I'm 0 to mid gm5

152
00:07:19,520 --> 00:07:16,590
involves Gondwanaland building into

153
00:07:22,280 --> 00:07:19,530
Pangaea whereas the paleoproterozoic saw

154
00:07:25,070 --> 00:07:22,290
the growth of the supercontinent nuna

155
00:07:27,380 --> 00:07:25,080
and really it's not clear whether nuna

156
00:07:29,570 --> 00:07:27,390
ever decayed to nothing or whether it

157
00:07:31,970 --> 00:07:29,580
simply continued to grow into the

158
00:07:35,660 --> 00:07:31,980
supercontinent rovenia which famously

159
00:07:38,600 --> 00:07:35,670
fragmented amid many at least five

160
00:07:44,630 --> 00:07:38,610
distinctly dated now neyo kerzo glacial

161
00:07:46,670 --> 00:07:44,640
deposits so the question again is are we

162
00:07:49,250 --> 00:07:46,680
seeing two distinct lay shal modes where

163
00:07:51,560 --> 00:07:49,260

all pre-cambrian glaciations denard at

164
00:07:55,010 --> 00:07:51,570
minimum by the icicles hanging from 90

165
00:07:56,960 --> 00:07:55,020
degrees at the pole down to some not

166
00:08:01,250 --> 00:07:56,970
necessarily quantitative estimate of

167
00:08:02,570 --> 00:08:01,260
their maximum equator word extent are

168
00:08:05,330 --> 00:08:02,580
these fundamentally different

169
00:08:07,130 --> 00:08:05,340
precambrian time a snowball mode versus

170
00:08:09,620 --> 00:08:07,140
phanerozoic time where they rarely

171
00:08:12,830 --> 00:08:09,630
encroach on the continents greater than

172
00:08:16,070 --> 00:08:12,840
about 40 degrees paleo latitude or are

173
00:08:18,490 --> 00:08:16,080
we seeing a shift whereas life evolves

174
00:08:21,500 --> 00:08:18,500
ever more complexity as the Sun becomes

175
00:08:25,159 --> 00:08:21,510
brighter and hotter as the atmosphere

176
00:08:30,379 --> 00:08:25,169
changes we see a gradual decrease

177
00:08:32,420 --> 00:08:30,389
through time okay the last part of the

178
00:08:36,409 --> 00:08:32,430
introductory information to keep in mind

179
00:08:38,230 --> 00:08:36,419
is the Hoffman and schrag formulate or

180
00:08:40,850 --> 00:08:38,240
enunciated version of a snowball

181
00:08:42,649 --> 00:08:40,860
hypothesis in which the entry into the

182
00:08:44,720 --> 00:08:42,659
snowball is catastrophic driven by

183
00:08:47,090 --> 00:08:44,730
unknown processes but but again

184
00:08:49,790 --> 00:08:47,100
presumably involving sudden drop in co2

185
00:08:53,840 --> 00:08:49,800
leading the catastrophic reverse or

186
00:08:56,150 --> 00:08:53,850
rather positive ice albedo feedback and

187
00:08:58,129 --> 00:08:56,160
then it takes some long duration of time

188
00:09:01,579 --> 00:08:58,139

for volcanic outgassing to build up

189
00:09:03,290 --> 00:09:01,589
enough greenhouse forcing to reverse the

190
00:09:06,680 --> 00:09:03,300
ice albedo run away which happens

191
00:09:08,870 --> 00:09:06,690
equally catastrophic Lee point is that

192
00:09:11,150 --> 00:09:08,880
during a snowball earth the earth is

193
00:09:13,970 --> 00:09:11,160
cold and this happens for a long time at

194
00:09:15,590 --> 00:09:13,980
the end you're hot and the transition

195
00:09:17,629 --> 00:09:15,600
between cold and hot house worlds is

196
00:09:20,350 --> 00:09:17,639
very quick this is simple and everyone

197
00:09:24,259 --> 00:09:20,360
is generally familiar with these ideas

198
00:09:28,189 --> 00:09:24,269
what might lead to the catastrophic drop

199
00:09:31,790 --> 00:09:28,199
in co2 pavlov at all astrobiology team

200
00:09:34,189 --> 00:09:31,800
members note in 2001 that presumably if

201
00:09:36,410 --> 00:09:34,199
the early Archaean atmosphere were

202
00:09:38,930 --> 00:09:36,420
dominated by methane greenhouse gases to

203
00:09:42,380 --> 00:09:38,940
compensate for the faint young Sun then

204
00:09:44,480 --> 00:09:42,390
any introduction of oxygen oxy atmo

205
00:09:48,800 --> 00:09:44,490
version so to speak into the atmosphere

206
00:09:51,710 --> 00:09:48,810
would lower the residence time of

207
00:09:53,449 --> 00:09:51,720
methane and over some period of time

208
00:09:57,800 --> 00:09:53,459
perhaps hundreds of millions of years

209
00:10:01,610 --> 00:09:57,810
the earth would have to readjust its

210
00:10:03,710 --> 00:10:01,620
fundamental greenhouse gas concentration

211
00:10:06,319 --> 00:10:03,720
response and so this might lead to the

212
00:10:09,470 --> 00:10:06,329
paleoproterozoic or qian glaciations

213
00:10:11,630 --> 00:10:09,480

this idea has been seized upon and

214
00:10:15,079 --> 00:10:11,640
elaborated by many astrobiology team

215
00:10:17,720 --> 00:10:15,089
members principally it's worth

216
00:10:19,939 --> 00:10:17,730
mentioning Andre Becker and also the

217
00:10:22,550 --> 00:10:19,949
Caltech group Kirsch Frank Bob cop Isaac

218
00:10:24,980 --> 00:10:22,560
hilburn and colleagues Eric itís also at

219
00:10:26,360 --> 00:10:24,990
university of hawaii now was involved in

220
00:10:28,519 --> 00:10:26,370
this and the best-preserved

221
00:10:30,949 --> 00:10:28,529
paleoproterozoic glacial deposit is

222
00:10:33,050 --> 00:10:30,959
arguably in south africa where the

223
00:10:36,500 --> 00:10:33,060
McEnaney dynamic tight unconformably

224
00:10:37,830 --> 00:10:36,510
over lies roughly 2.4 although there are

225
00:10:40,080 --> 00:10:37,840
new dates coming out

226
00:10:42,330 --> 00:10:40,090
2.3 billion year old sedimentary

227
00:10:44,880 --> 00:10:42,340
successions and inner fingers with

228
00:10:47,910 --> 00:10:44,890
volcanic that have a very robust paleo

229
00:10:49,890 --> 00:10:47,920
magnetic signal indicating their deposit

230
00:10:52,260 --> 00:10:49,900
11 plus or minus five degrees paleo

231
00:10:55,950 --> 00:10:52,270
latitude immediately above the volcanic

232
00:10:58,350 --> 00:10:55,960
their reworked volcanic clasts deposits

233
00:11:00,660 --> 00:10:58,360
drop stones in the iron-rich sedimentary

234
00:11:02,970 --> 00:11:00,670
strata which become banded iron and

235
00:11:05,030 --> 00:11:02,980
manganese formations leading into a

236
00:11:08,190 --> 00:11:05,040
platform of carbonate succession of

237
00:11:09,990 --> 00:11:08,200
perhaps 2300 although there are new

238
00:11:11,670 --> 00:11:10,000

Detroit Newark on ages of closer to

239
00:11:14,310 --> 00:11:11,680
twenty two hundred million years for the

240
00:11:15,960 --> 00:11:14,320
top of the succession and really the

241
00:11:20,010 --> 00:11:15,970
principal feature that the Caltech group

242
00:11:21,990 --> 00:11:20,020
has his focused analysis on has been the

243
00:11:24,540 --> 00:11:22,000
banat iron manganese formations as shown

244
00:11:28,830 --> 00:11:24,550
in scision mama tuan mines here from the

245
00:11:30,900 --> 00:11:28,840
kalahari province the idea is that the

246
00:11:32,580 --> 00:11:30,910
manganese especially requires option

247
00:11:34,410 --> 00:11:32,590
something will return to a minute but

248
00:11:36,840 --> 00:11:34,420
broadly speaking was very consistent

249
00:11:38,640 --> 00:11:36,850
with the with the general trend of mass

250
00:11:40,920 --> 00:11:38,650
independent sulfur fractionation

251
00:11:43,530 --> 00:11:40,930
elaborate by james farr car and many

252
00:11:47,820 --> 00:11:43,540
colleagues including Shuhei oh no now of

253
00:11:52,980 --> 00:11:47,830
MIT and most recently yesterday papineau

254
00:11:56,430 --> 00:11:52,990
it all from the Colorado National Mei

255
00:11:57,750 --> 00:11:56,440
group went to the groaning succession

256
00:11:59,340 --> 00:11:57,760
essentially have pulled out a very

257
00:12:02,100 --> 00:11:59,350
similar story in which there's a

258
00:12:04,260 --> 00:12:02,110
dramatic departure from varied Matt's

259
00:12:09,690 --> 00:12:04,270
independent isotope fractionation values

260
00:12:15,000 --> 00:12:09,700
to the expected oxygenic zero

261
00:12:16,700 --> 00:12:15,010
essentially cap 33 at approximately the

262
00:12:19,470 --> 00:12:16,710
time and about the location

263
00:12:21,690 --> 00:12:19,480

stratigraphically of the McEnaney

264
00:12:25,230 --> 00:12:21,700
dynamic tight or it's presumed global

265
00:12:27,120 --> 00:12:25,240
correlative glaciations the final

266
00:12:29,640 --> 00:12:27,130
classical evidence for oxygenation

267
00:12:34,280 --> 00:12:29,650
accompanying the paleoproterozoic first

268
00:12:37,620 --> 00:12:34,290
major pre kamran glaciation is the

269
00:12:39,120 --> 00:12:37,630
appearance of these giant banner

270
00:12:40,920 --> 00:12:39,130
informations immediately after the

271
00:12:44,190 --> 00:12:40,930
glacial deposit and then the

272
00:12:45,120 --> 00:12:44,200
disappearance shortly after during the

273
00:12:47,450 --> 00:12:45,130
the paley

274
00:12:49,800 --> 00:12:47,460
purrs OH Akande mesoproterozoic eras

275
00:12:52,110 --> 00:12:49,810
curiously the banded iron formations

276
00:12:54,060 --> 00:12:52,120
reappear in the near perozo but only in

277
00:12:56,220 --> 00:12:54,070
successions intimately associated with

278
00:12:58,110 --> 00:12:56,230
glacial deposits themselves here for

279
00:13:00,170 --> 00:12:58,120
instance there's a rafted carbonate drop

280
00:13:02,550 --> 00:13:00,180
stone the Mackenzie mountains of Canada

281
00:13:04,290 --> 00:13:02,560
deforming banette I information is the

282
00:13:08,580 --> 00:13:04,300
rabbit and formation in the New York or

283
00:13:11,400 --> 00:13:08,590
zone the question though is oxygen

284
00:13:13,260 --> 00:13:11,410
required somehow associated with both

285
00:13:16,590 --> 00:13:13,270
these near purrs oak and paleozoic

286
00:13:18,300 --> 00:13:16,600
glaciations to produce the the banded

287
00:13:21,690 --> 00:13:18,310
iron formations of course there are many

288
00:13:25,520 --> 00:13:21,700

accidents on an electron ladder here for

289
00:13:27,510 --> 00:13:25,530
example is the guy dose at all 1999

290
00:13:30,170 --> 00:13:27,520
electrochemical laddered approximately

291
00:13:33,090 --> 00:13:30,180
neutral pH where you can see that

292
00:13:35,160 --> 00:13:33,100
species like uranium which have actually

293
00:13:37,050 --> 00:13:35,170
relatively negative Pease here could be

294
00:13:40,050 --> 00:13:37,060
oxidized if they're simply coupled

295
00:13:42,090 --> 00:13:40,060
biochemically to iron reduction on the

296
00:13:46,760 --> 00:13:42,100
other hand Kirsten Corral and comp at

297
00:13:49,470 --> 00:13:46,770
all recently have noted that manganese

298
00:13:51,540 --> 00:13:49,480
oxidation rather formation of manganese

299
00:13:53,760 --> 00:13:51,550
oxide such as in the manganese banded

300
00:13:57,000 --> 00:13:53,770
iron deposits and manganese deposits on

301
00:14:01,220 --> 00:13:57,010
the kalahari crate I'm must be coupled

302
00:14:04,290 --> 00:14:01,230
either to nitrate reduction or

303
00:14:06,810 --> 00:14:04,300
essentially presence free oxygen since

304
00:14:09,360 --> 00:14:06,820
nitrate to be present presumably

305
00:14:11,940 --> 00:14:09,370
requires the presence oxygen this is the

306
00:14:13,560 --> 00:14:11,950
strongest direct consideration for

307
00:14:15,870 --> 00:14:13,570
presence of molecular action a

308
00:14:18,840 --> 00:14:15,880
quantitative levels in the Paleozoic

309
00:14:23,520 --> 00:14:18,850
atmosphere associated with McEnaney

310
00:14:25,080 --> 00:14:23,530
glacial dynamic tide rises so let's keep

311
00:14:27,060 --> 00:14:25,090
keep holding on to this idea that

312
00:14:28,980 --> 00:14:27,070
paleoproterozoic glacial is especially

313
00:14:31,410 --> 00:14:28,990

in south africa at about twenty two

314
00:14:33,150 --> 00:14:31,420
hundred million years seemingly require

315
00:14:35,460 --> 00:14:33,160
presence of free oxygen in the

316
00:14:38,910 --> 00:14:35,470
atmosphere in order to produce banded

317
00:14:41,370 --> 00:14:38,920
manganese deposits recall the character

318
00:14:44,090 --> 00:14:41,380
of a glacial glaciation during its life

319
00:14:48,030 --> 00:14:44,100
span is cold and dry and presumably

320
00:14:50,850 --> 00:14:48,040
leads to ever lower relative quantities

321
00:14:55,280 --> 00:14:50,860
of oxygen in the atmosphere since to

322
00:14:58,440 --> 00:14:55,290
some extent at least you expect to be

323
00:15:01,370 --> 00:14:58,450
impeding both synthetic production

324
00:15:05,550 --> 00:15:01,380
action if it even exists to begin with

325
00:15:07,680 --> 00:15:05,560
and also burial of carbon and and build

326
00:15:11,850 --> 00:15:07,690
up a reduced species if they're exposed

327
00:15:14,700 --> 00:15:11,860
periodically in small open ocean pockets

328
00:15:17,280 --> 00:15:14,710
will likewise very attend to bury oxygen

329
00:15:19,080 --> 00:15:17,290
rather than produce it so there's a cold

330
00:15:21,720 --> 00:15:19,090
dry low oxygen environment expected

331
00:15:24,210 --> 00:15:21,730
during glaciation and recently Danny

332
00:15:26,850 --> 00:15:24,220
Lane and colleagues of Caltech is Carl

333
00:15:30,630 --> 00:15:26,860
furnace introduction have noted a novel

334
00:15:34,250 --> 00:15:30,640
mechanism not a novel mechanism in

335
00:15:37,020 --> 00:15:34,260
insofar as it's been studied many

336
00:15:39,420 --> 00:15:37,030
extraterrestrial analogs on Mars for

337
00:15:41,790 --> 00:15:39,430
instance on Europa and also on the

338
00:15:45,710 --> 00:15:41,800

Greenland ice sheets which is that

339
00:15:48,780 --> 00:15:45,720
photolysis of water in cold dry and

340
00:15:52,530 --> 00:15:48,790
low-oxygen environments produces

341
00:15:54,510 --> 00:15:52,540
hydrogen peroxide hydrogen peroxide has

342
00:15:56,880 --> 00:15:54,520
a freezing point very close to that of

343
00:16:01,740 --> 00:15:56,890
ice and so if its present in sufficient

344
00:16:05,730 --> 00:16:01,750
quantities that it can rain out and be

345
00:16:08,040 --> 00:16:05,740
buried in ice before it is in turn full

346
00:16:11,760 --> 00:16:08,050
totalized in the hydroxyl radicals or

347
00:16:13,590 --> 00:16:11,770
else recombined with free hydrogen to

348
00:16:16,230 --> 00:16:13,600
form water vapor in the atmosphere then

349
00:16:18,630 --> 00:16:16,240
you can preserve a very strong oxidant

350
00:16:20,310 --> 00:16:18,640
for geological timescales and ice which

351
00:16:23,520 --> 00:16:20,320
might then melt away at the end of

352
00:16:25,590 --> 00:16:23,530
snowball earth glaciation this process

353
00:16:28,920 --> 00:16:25,600
happens today is observable in for

354
00:16:30,630 --> 00:16:28,930
instance Antarctic ice cores here many

355
00:16:32,880 --> 00:16:30,640
authors have noted that there is a

356
00:16:35,940 --> 00:16:32,890
historical increase in the concentration

357
00:16:39,590 --> 00:16:35,950
of ozone in South Pole Antarctic ice

358
00:16:42,210 --> 00:16:39,600
cores presumably related to low ozone

359
00:16:44,010 --> 00:16:42,220
relaying the ozone hole allowing greater

360
00:16:46,290 --> 00:16:44,020
penetration of ultraviolet light which

361
00:16:49,230 --> 00:16:46,300
permits the fatalis which enhances the

362
00:16:51,660 --> 00:16:49,240
fatalis asst of the water and likewise

363
00:16:54,000 --> 00:16:51,670

there's a there's a seasonal cycle you

364
00:16:57,000 --> 00:16:54,010
can see the scale bars here at shallow I

365
00:16:59,540 --> 00:16:57,010
score deaths are different up to 200

366
00:17:02,640 --> 00:16:59,550
than the scales at deep drill hole decks

367
00:17:05,430 --> 00:17:02,650
reflecting this presumably anthropogenic

368
00:17:08,699 --> 00:17:05,440
increase in the peroxide concentration

369
00:17:11,910 --> 00:17:08,709
ice and during melting of ice sheets

370
00:17:12,360 --> 00:17:11,920
during the summer much of this peroxide

371
00:17:17,850 --> 00:17:12,370
is really

372
00:17:20,460 --> 00:17:17,860
east into the ocean laying and

373
00:17:24,480 --> 00:17:20,470
colleagues considered a one-dimensional

374
00:17:27,660 --> 00:17:24,490
model of an archaean atmosphere to start

375
00:17:30,150 --> 00:17:27,670
with only containing hydrogen molecular

376
00:17:32,670 --> 00:17:30,160
hydrogen and nitrogen but receiving

377
00:17:34,860 --> 00:17:32,680
constant input of carbon dioxide from

378
00:17:37,110 --> 00:17:34,870
volcanic outgassing and they let that

379
00:17:39,750 --> 00:17:37,120
evolve solving for mass continuity

380
00:17:41,940 --> 00:17:39,760
equations for ten to thirty million

381
00:17:44,850 --> 00:17:41,950
years here's one standard result which

382
00:17:48,150 --> 00:17:44,860
they produce simulating the snowball for

383
00:17:50,340 --> 00:17:48,160
about 30 million years they build up

384
00:17:52,919 --> 00:17:50,350
hydrogen peroxide to a mixing ratio of

385
00:17:55,169 --> 00:17:52,929
10 to the minus 10 consider ly more than

386
00:17:56,430 --> 00:17:55,179
today at close to the surface of the

387
00:17:58,350 --> 00:17:56,440
earth because the characteristic

388
00:18:00,870 --> 00:17:58,360

diffusion scale for hydrogen peroxide is

389
00:18:03,090 --> 00:18:00,880
approximately one kilometer in today's

390
00:18:06,380 --> 00:18:03,100
atmosphere before it becomes hydrolyzed

391
00:18:08,910 --> 00:18:06,390
photo lized rather by ultraviolet light

392
00:18:11,549 --> 00:18:08,920
you have to build up the concentration

393
00:18:13,860 --> 00:18:11,559
not merely at altitude but within a

394
00:18:15,060 --> 00:18:13,870
kilometer or even closer preferably to

395
00:18:16,770 --> 00:18:15,070
the Earth's surface in order to be

396
00:18:23,190 --> 00:18:16,780
buried on any ice that might be present

397
00:18:25,110 --> 00:18:23,200
as in this model sensitivity analyses of

398
00:18:26,970 --> 00:18:25,120
laying it all suggested that the

399
00:18:30,720 --> 00:18:26,980
peroxide deposition rate will increase

400
00:18:33,299 --> 00:18:30,730
with ever greater hydrogen escape to

401
00:18:35,010 --> 00:18:33,309
space which might be modulated by things

402
00:18:39,570 --> 00:18:35,020
like geomagnetic field strength and

403
00:18:41,460 --> 00:18:39,580
other atmospheric conditions depressed

404
00:18:43,950 --> 00:18:41,470
hydrologic cycle in other words the more

405
00:18:45,660 --> 00:18:43,960
active the water cycle the less peroxide

406
00:18:49,080 --> 00:18:45,670
will tend to be buried depress

407
00:18:50,970 --> 00:18:49,090
temperature so the colder it is the more

408
00:18:53,160 --> 00:18:50,980
peroxide will be buried and of course

409
00:18:56,669 --> 00:18:53,170
depletion of stratospheric ozone is in

410
00:19:00,660 --> 00:18:56,679
the modern case in Antarctica so given

411
00:19:02,280 --> 00:19:00,670
the order of magnitude variations with

412
00:19:04,500 --> 00:19:02,290
that sensitivity analysis it's

413
00:19:07,070 --> 00:19:04,510

nonetheless certainly conceivable in a

414
00:19:10,799 --> 00:19:07,080
tens of millions of year hard snowball

415
00:19:12,660 --> 00:19:10,809
not necessarily an impossible thing by

416
00:19:15,990 --> 00:19:12,670
the simple energy balance or the

417
00:19:18,410 --> 00:19:16,000
advanced GCMs as we talked about early

418
00:19:21,360 --> 00:19:18,420
in the talked here to produce up to

419
00:19:22,890 --> 00:19:21,370
point 1 the whole atmosphere worth of

420
00:19:24,780 --> 00:19:22,900
oxygen equivalent hydrogen peroxide

421
00:19:25,250 --> 00:19:24,790
which would be released and turned into

422
00:19:29,630 --> 00:19:25,260
action

423
00:19:32,810 --> 00:19:29,640
at the end of a snowball glaciation the

424
00:19:34,910 --> 00:19:32,820
scenario that laying it all hypothesize

425
00:19:37,730 --> 00:19:34,920
them for implications is something like

426
00:19:39,980 --> 00:19:37,740
this suppose the earliest pre-cambrian

427
00:19:42,230 --> 00:19:39,990
glaciation such as the pongal in South

428
00:19:45,040 --> 00:19:42,240
Africa without any firm paleo magnetic

429
00:19:49,130 --> 00:19:45,050
evidence for low or high paleo latitude

430
00:19:50,660 --> 00:19:49,140
but it seems to be probably unique at

431
00:19:54,530 --> 00:19:50,670
least in the kray times that preserve

432
00:19:57,290 --> 00:19:54,540
rocks that age and also possibly the

433
00:19:59,690 --> 00:19:57,300
earlier of the huronian hurwitz no we

434
00:20:01,520 --> 00:19:59,700
passed supergroup glaciations in the

435
00:20:04,610 --> 00:20:01,530
paleoproterozoic that do not have

436
00:20:07,550 --> 00:20:04,620
evidence for low paleo latitude so they

437
00:20:10,550 --> 00:20:07,560
also might not be true whole snowball

438
00:20:12,110 --> 00:20:10,560

earth glaciations these might've just

439
00:20:14,600 --> 00:20:12,120
like the modern Antarctic scenario

440
00:20:16,670 --> 00:20:14,610
produce some hydrogen peroxide and a

441
00:20:22,940 --> 00:20:16,680
methane atmosphere dominated our key

442
00:20:25,310 --> 00:20:22,950
into early paleozoic earth this would be

443
00:20:26,840 --> 00:20:25,320
the first strong oxidant which would

444
00:20:30,050 --> 00:20:26,850
exert some sort of selection pressure

445
00:20:34,280 --> 00:20:30,060
conceivably driving evolution of enzymes

446
00:20:36,290 --> 00:20:34,290
that have to be present to deal with

447
00:20:39,200 --> 00:20:36,300
peroxide is a natural biochemical

448
00:20:42,260 --> 00:20:39,210
product of reactions such as oxygenic

449
00:20:46,010 --> 00:20:42,270
photosynthesis or mutation of enzymes

450
00:20:48,380 --> 00:20:46,020
involved in that mutation proteins

451
00:20:50,450 --> 00:20:48,390
involved that oxygen of photosynthesis

452
00:20:52,280 --> 00:20:50,460
could be exempted only once you Duvall

453
00:20:56,720 --> 00:20:52,290
these things such as manganese catalase

454
00:20:58,370 --> 00:20:56,730
or superoxide dismutase and then an

455
00:21:01,810 --> 00:20:58,380
atmospheric methane reservoir could

456
00:21:04,160 --> 00:21:01,820
crash suddenly on the time scale genetic

457
00:21:07,450 --> 00:21:04,170
population of the earth essentially in

458
00:21:09,710 --> 00:21:07,460
bacteria as opposed to the the photo

459
00:21:11,450 --> 00:21:09,720
atmospheric chemical x killed hundreds

460
00:21:14,360 --> 00:21:11,460
of millions years initially proposed by

461
00:21:16,610 --> 00:21:14,370
Pavlov and others this would trigger a

462
00:21:18,590 --> 00:21:16,620
paleozoic snowball in the classical

463
00:21:20,290 --> 00:21:18,600

sense of you've suddenly lowered the

464
00:21:23,300 --> 00:21:20,300
greenhouse forcing of the earth is

465
00:21:25,610 --> 00:21:23,310
dependent upon producing lots of

466
00:21:27,080 --> 00:21:25,620
peroxide in the ensuing multi millions

467
00:21:29,660 --> 00:21:27,090
of years or tens of millions of years

468
00:21:31,490 --> 00:21:29,670
snowball earth helping precipitate the

469
00:21:34,040 --> 00:21:31,500
kalahari manganese eventually at the end

470
00:21:36,380 --> 00:21:34,050
so you don't just need oxygen is

471
00:21:38,760 --> 00:21:36,390
previously supposed peroxide is

472
00:21:41,400 --> 00:21:38,770
certainly also very capable accident

473
00:21:47,430 --> 00:21:41,410
of even generally positive eh species

474
00:21:49,530 --> 00:21:47,440
like manganese and curiously perhaps

475
00:21:52,620 --> 00:21:49,540
overcoming the night the nitrate

476
00:21:54,150 --> 00:21:52,630
limitation paradox to axiom aversion

477
00:21:55,680 --> 00:21:54,160
that's been enunciated by fenelon

478
00:21:58,410 --> 00:21:55,690
colleagues astrobiology institute

479
00:22:00,950 --> 00:21:58,420
members in which they note that the very

480
00:22:03,930 --> 00:22:00,960
first introduction of molecular oxygen

481
00:22:06,300 --> 00:22:03,940
would seem to be self-limiting bio

482
00:22:08,880 --> 00:22:06,310
spherically because many nitrogenase

483
00:22:12,780 --> 00:22:08,890
cofactors depend on redox-sensitive

484
00:22:14,520 --> 00:22:12,790
metals like for instance manganese and

485
00:22:16,380 --> 00:22:14,530
furthermore once you have a little bit

486
00:22:19,200 --> 00:22:16,390
auction you can begin doing pathways

487
00:22:20,760 --> 00:22:19,210
like aerobic denitrification which would

488
00:22:23,750 --> 00:22:20,770

tend the nation limit cyanobacteria

489
00:22:26,910 --> 00:22:23,760
which are presumed to be the major

490
00:22:28,860 --> 00:22:26,920
likely auction pumpers in a post

491
00:22:30,840 --> 00:22:28,870
McEnaney world until there was

492
00:22:32,130 --> 00:22:30,850
sufficient oxygen to fix the nation from

493
00:22:34,320 --> 00:22:32,140
nitrates so it's a chicken in the egg

494
00:22:35,790 --> 00:22:34,330
given a little bit action it seems to

495
00:22:38,880 --> 00:22:35,800
become more difficult to gain more

496
00:22:41,490 --> 00:22:38,890
oxygen however this sudden influx of

497
00:22:43,890 --> 00:22:41,500
hydrogen peroxide could overwhelm the

498
00:22:46,770 --> 00:22:43,900
nitrate limitation paradox and permit

499
00:22:48,810 --> 00:22:46,780
the oxy Atma version as obviously is

500
00:22:52,500 --> 00:22:48,820
evidenced in the geochemical and

501
00:22:55,470 --> 00:22:52,510
geological rock record so much for the

502
00:22:57,870 --> 00:22:55,480
paleoproterozoic we have the Neo kerzo

503
00:23:02,400 --> 00:22:57,880
where a high methane atmosphere is no

504
00:23:06,840 --> 00:23:02,410
longer very tenable for the pre snowball

505
00:23:09,570 --> 00:23:06,850
say 750 to 800 million year earth is

506
00:23:11,520 --> 00:23:09,580
there a similar oxidation or oxygenation

507
00:23:13,680 --> 00:23:11,530
and the two are somewhat distinctive is

508
00:23:15,750 --> 00:23:13,690
we've discussed here link to the New

509
00:23:16,770 --> 00:23:15,760
Yorkers Oh glacial deposits well of

510
00:23:19,110 --> 00:23:16,780
course there are the banded iron

511
00:23:22,070 --> 00:23:19,120
formations in the sturdy and in the

512
00:23:26,030 --> 00:23:22,080
classics 30 in approximately 700 or

513
00:23:28,710 --> 00:23:26,040

maybe 650 million early glacial deposits

514
00:23:30,240 --> 00:23:28,720
there are other curious features of

515
00:23:32,070 --> 00:23:30,250
these glaciations including cap

516
00:23:33,570 --> 00:23:32,080
carbonates here's my favorite picture of

517
00:23:35,970 --> 00:23:33,580
a cap carbonate from this fall garden

518
00:23:38,100 --> 00:23:35,980
succession that Pippa Halverson Adam Lu

519
00:23:42,600 --> 00:23:38,110
from colleagues have worked on partly

520
00:23:44,820 --> 00:23:42,610
funded by the NAI in which the idea of

521
00:23:46,680 --> 00:23:44,830
the cap carbonate is during the latest

522
00:23:49,380 --> 00:23:46,690
near provo glacial deposits and at least

523
00:23:51,600 --> 00:23:49,390
one of the paleoproterozoic glacial

524
00:23:54,750 --> 00:23:51,610
deposits it's not clear if that

525
00:23:56,460 --> 00:23:54,760
on the Bruce dynamic tight and the

526
00:23:59,669 --> 00:23:56,470
huronian supergroup correlates to the

527
00:24:02,490 --> 00:23:59,679
McEnaney demonstrably low pehli latitude

528
00:24:04,470 --> 00:24:02,500
glaciation or not but in one paleozoic

529
00:24:07,140 --> 00:24:04,480
and many late New Yorkers Oh glacial

530
00:24:09,480 --> 00:24:07,150
deposits even if they're salissa classic

531
00:24:11,400 --> 00:24:09,490
shale sand dominated successions during

532
00:24:14,010 --> 00:24:11,410
the glaciation before the glaciation

533
00:24:15,860 --> 00:24:14,020
after the glaciation immediately in top

534
00:24:18,330 --> 00:24:15,870
the glacial deposits there is a thin

535
00:24:20,610 --> 00:24:18,340
carbonate that generally abdullah stones

536
00:24:23,430 --> 00:24:20,620
sometimes of limestone seeming to

537
00:24:25,820 --> 00:24:23,440
indicate a flux of alkalinity of the

538
00:24:28,830 --> 00:24:25,830

oceans overcoming solicit clastic

539
00:24:30,750 --> 00:24:28,840
deposition there's also as you can see

540
00:24:33,990 --> 00:24:30,760
perhaps in this picture a characteristic

541
00:24:35,880 --> 00:24:34,000
reddening of carbonates and solicit

542
00:24:38,340 --> 00:24:35,890
classics immediately atop the cap

543
00:24:42,000 --> 00:24:38,350
carbonate leading back into here in

544
00:24:46,190 --> 00:24:42,010
Svalbard drab dark colored black solicit

545
00:24:52,830 --> 00:24:50,610
classically a similar startling cap

546
00:24:55,470 --> 00:24:52,840
carbonate is preserved in Newfoundland

547
00:24:59,010 --> 00:24:55,480
where at approximately 581 millions of

548
00:25:02,600 --> 00:24:59,020
years 3 kilometers of deepwater black

549
00:25:05,549 --> 00:25:02,610
organic-rich salissa classic turbidites

550
00:25:07,409 --> 00:25:05,559
became glacially supported in other

551
00:25:09,360 --> 00:25:07,419
words their stride class and drop stones

552
00:25:11,669 --> 00:25:09,370
introduced into the turbidites and then

553
00:25:14,280 --> 00:25:11,679
there's a very thin 75 centimeter

554
00:25:16,520 --> 00:25:14,290
thinner here in this section little

555
00:25:19,770 --> 00:25:16,530
comet island only 10 centimetres thick

556
00:25:22,380 --> 00:25:19,780
cap dolostone immediately above the

557
00:25:24,960 --> 00:25:22,390
topmost glacial deposits and it goes

558
00:25:27,780 --> 00:25:24,970
into young Inge to the left in the

559
00:25:29,640 --> 00:25:27,790
picture here although it's not as

560
00:25:33,810 --> 00:25:29,650
evidence from the outcrop weathering a

561
00:25:35,490 --> 00:25:33,820
red fine grain sequence so a red and

562
00:25:37,560 --> 00:25:35,500
interval just like the previous picture

563
00:25:40,620 --> 00:25:37,570

from small bar before returning to a

564
00:25:42,659 --> 00:25:40,630
full five kilometers of organic rich

565
00:25:46,169 --> 00:25:42,669
turbidites just like before the

566
00:25:48,330 --> 00:25:46,179
glaciation so at 581 million years

567
00:25:50,909 --> 00:25:48,340
there's a glaciation called gas skiers

568
00:25:53,250 --> 00:25:50,919
that shows the same classic Maron own

569
00:25:55,740 --> 00:25:53,260
reddening which is somewhat like

570
00:25:57,659 --> 00:25:55,750
reminiscent of the oxygen oxidation

571
00:25:59,960 --> 00:25:57,669
oxidation banded I information

572
00:26:03,810 --> 00:25:59,970
Association of the paleoproterozoic

573
00:26:04,460 --> 00:26:03,820
there are no airtight paleomagnetic

574
00:26:06,440 --> 00:26:04,470
results

575
00:26:08,210 --> 00:26:06,450
some gas gears and it's not clear if

576
00:26:11,510 --> 00:26:08,220
this is a truce noble earth or if this

577
00:26:13,310 --> 00:26:11,520
is right on the road between the New

578
00:26:16,430 --> 00:26:13,320
Yorkers okay liters of low latitude

579
00:26:19,190 --> 00:26:16,440
glaciations and the Ordovician Permian

580
00:26:21,080 --> 00:26:19,200
pile Pleistocene moderate pehli latitude

581
00:26:24,440 --> 00:26:21,090
glaciations as I talked about early in

582
00:26:29,690 --> 00:26:24,450
the talked recently Campfield and

583
00:26:32,630 --> 00:26:29,700
colleagues have performed a method which

584
00:26:35,450 --> 00:26:32,640
they term highly reactive iron ratios

585
00:26:37,549 --> 00:26:35,460
which essentially is a measure of the

586
00:26:44,750 --> 00:26:37,559
fraction of iron in Iraq which is bound

587
00:26:47,180 --> 00:26:44,760
up in salissa clastic debris unreactive

588
00:26:49,760 --> 00:26:47,190

clays and silicates as opposed to all

589
00:26:52,399 --> 00:26:49,770
other forms sulfides carbonates oxide

590
00:26:53,779 --> 00:26:52,409
and so forth and the idea is in modern

591
00:26:56,029 --> 00:26:53,789
settings that are well understood

592
00:26:59,029 --> 00:26:56,039
geochemical II like the Black Sea this

593
00:27:02,659 --> 00:26:59,039
ratio is relatively sensitive to the

594
00:27:05,000 --> 00:27:02,669
oxidation state and and oxygenation of

595
00:27:07,820 --> 00:27:05,010
the seawater and they see two first

596
00:27:10,880 --> 00:27:07,830
order a step function decrease of their

597
00:27:12,289 --> 00:27:10,890
iron highly reactive to iron total this

598
00:27:14,690 --> 00:27:12,299
is another way of expressing this

599
00:27:18,710 --> 00:27:14,700
fraction of solicit lastic bearing iron

600
00:27:20,950 --> 00:27:18,720
at the very top or between their top

601
00:27:24,049 --> 00:27:20,960
most gas tears sample and the lowermost

602
00:27:26,810 --> 00:27:24,059
super gas skiers deepwater organic-rich

603
00:27:30,370 --> 00:27:26,820
turbidites they suggest this indicates

604
00:27:34,130 --> 00:27:30,380
there was at least some oxygenation

605
00:27:36,169 --> 00:27:34,140
quantifiably accompanying the end the

606
00:27:39,230 --> 00:27:36,179
deglaciation of the ghast year's event

607
00:27:40,880 --> 00:27:39,240
they also go on to present the order

608
00:27:43,220 --> 00:27:40,890
magnitude argument for what everyone is

609
00:27:46,070 --> 00:27:43,230
assumed is the case which is that the

610
00:27:48,049 --> 00:27:46,080
ensuing evolution of complex macro biota

611
00:27:50,270 --> 00:27:48,059
the ed Accra fauna and of course the

612
00:27:52,610 --> 00:27:50,280
later Cambrian explosion would seem to

613
00:27:57,500 --> 00:27:52,620

require greater oxygen levels that are

614
00:28:00,799 --> 00:27:57,510
assumed to be present in the preceding

615
00:28:05,690 --> 00:28:00,809
parts of near persia in order to permit

616
00:28:07,460 --> 00:28:05,700
a surface area to volume sort of

617
00:28:09,799 --> 00:28:07,470
considerations for building complex body

618
00:28:12,770 --> 00:28:09,809
plans the evidence for low New Yorkers

619
00:28:16,190 --> 00:28:12,780
Oh glaciation is dominantly coming from

620
00:28:18,980 --> 00:28:16,200
work of Mattrick and colleagues recently

621
00:28:21,399 --> 00:28:18,990
turns out Northwest University who study

622
00:28:25,090 --> 00:28:21,409
carbonate associate sulfate sulfur

623
00:28:27,789 --> 00:28:25,100
isotopes which indicate very low sulfate

624
00:28:31,190 --> 00:28:27,799
concentrations in New Yorkers Oh acceder

625
00:28:35,899 --> 00:28:31,200
inferring than low oxygen concentrations

626
00:28:40,600 --> 00:28:35,909
in the overlying atmosphere this is a

627
00:28:42,769 --> 00:28:40,610
the gas Kyra's event is one of as

628
00:28:45,889 --> 00:28:42,779
originally I noted on one of the early

629
00:28:47,779 --> 00:28:45,899
slides many neo purzel glaciations of

630
00:28:50,269 --> 00:28:47,789
which all workers tend to agree at least

631
00:28:51,710 --> 00:28:50,279
three exists so-called in this

632
00:28:56,629 --> 00:28:51,720
compilation by Halverson it on

633
00:28:59,210 --> 00:28:56,639
colleagues supported by the nai and this

634
00:29:01,460 --> 00:28:59,220
diagram has been somewhat modified for a

635
00:29:07,220 --> 00:29:01,470
particular correlation of this part of

636
00:29:08,330 --> 00:29:07,230
the blue namibian and svalbard curves to

637
00:29:10,129 --> 00:29:08,340
actually perceive the stirring

638
00:29:13,129 --> 00:29:10,139

glaciation however the whole character

639
00:29:15,370 --> 00:29:13,139
of the of the idea of the swings of

640
00:29:18,070 --> 00:29:15,380
carbon does not change nor actually the

641
00:29:21,560 --> 00:29:18,080
substantial correlation of the

642
00:29:25,430 --> 00:29:21,570
successions and that's been modified in

643
00:29:27,110 --> 00:29:25,440
Halverson 2007 recently there are at

644
00:29:29,930 --> 00:29:27,120
least three glaciations called sturdy

645
00:29:31,430 --> 00:29:29,940
and Marin own and here vranger which is

646
00:29:34,009 --> 00:29:31,440
presumed to be equivalent to the gas

647
00:29:37,460 --> 00:29:34,019
gears event we just talked about note

648
00:29:40,759 --> 00:29:37,470
that all three are associated with quite

649
00:29:45,320 --> 00:29:40,769
severe negative carbonate carbon isotope

650
00:29:50,120 --> 00:29:45,330
excursions beforehand here this event is

651
00:29:51,440 --> 00:29:50,130
considered the wanaka / Johnny / sharam

652
00:29:54,289 --> 00:29:51,450
anomaly for three different locations

653
00:29:55,850 --> 00:29:54,299
where it is inferred to be present by

654
00:29:59,690 --> 00:29:55,860
global correlation which is not airtight

655
00:30:01,669 --> 00:29:59,700
but is certainly plausible and there are

656
00:30:04,279 --> 00:30:01,679
various other features of returning

657
00:30:06,080 --> 00:30:04,289
positive excursions after each of these

658
00:30:08,419 --> 00:30:06,090
glaciations that might be related to

659
00:30:15,190 --> 00:30:08,429
things like oxidation oxygenation of the

660
00:30:17,960 --> 00:30:15,200
ocean in particular the

661
00:30:19,580 --> 00:30:17,970
Wanaka sure an anomaly associated with

662
00:30:22,100 --> 00:30:19,590
his gas cures glaciation we've just

663
00:30:25,220 --> 00:30:22,110

talked about has been documented more

664
00:30:27,320 --> 00:30:25,230
than 30 outcrop sections with extensive

665
00:30:29,420 --> 00:30:27,330
sequence stratigraphy done by our one

666
00:30:31,280 --> 00:30:29,430
leg ruin colleagues formerly at a

667
00:30:34,600 --> 00:30:31,290
two-hot Zurich now at University of

668
00:30:38,300 --> 00:30:34,610
California Riverside in which there's a

669
00:30:41,150 --> 00:30:38,310
decrease in carbonate carbon isotopes by

670
00:30:43,250 --> 00:30:41,160
up to 14 per mil an extraordinary number

671
00:30:46,100 --> 00:30:43,260
reaching a Navy er of negative 12 per

672
00:30:48,800 --> 00:30:46,110
mil far below the expected mantel value

673
00:30:50,950 --> 00:30:48,810
of approximately negative six this would

674
00:30:54,260 --> 00:30:50,960
seem to indicate introduction of a major

675
00:30:57,530 --> 00:30:54,270
energy either organic carbon reservoir

676
00:31:00,350 --> 00:30:57,540
into the ocean overwhelming the total

677
00:31:04,460 --> 00:31:00,360
size of the inorganic carbon carbonate

678
00:31:06,200 --> 00:31:04,470
reservoir David faking colleagues have

679
00:31:12,050 --> 00:31:06,210
recently produced a really extraordinary

680
00:31:15,620 --> 00:31:12,060
data set which speaks with great detail

681
00:31:19,130 --> 00:31:15,630
to what's hinted at as a specific gas

682
00:31:22,160 --> 00:31:19,140
skiers event but spanning the entire or

683
00:31:25,190 --> 00:31:22,170
almost the entire Ediacaran period using

684
00:31:27,500 --> 00:31:25,200
drill core from Oman the subsurface of

685
00:31:28,880 --> 00:31:27,510
the same area where Iran log ruined

686
00:31:30,770 --> 00:31:28,890
colleagues have done their outcrop

687
00:31:33,080 --> 00:31:30,780
mapping of the Shoreham sequence

688
00:31:36,860 --> 00:31:33,090

stratigraphic carbon isotope anomaly

689
00:31:40,190 --> 00:31:36,870
here in drill core David fight who just

690
00:31:42,530 --> 00:31:40,200
got his PhD at MIT and caltech has

691
00:31:45,140 --> 00:31:42,540
produced inorganic carbon isotopes

692
00:31:47,540 --> 00:31:45,150
organic carbon isotopes sulfate sulfur

693
00:31:49,580 --> 00:31:47,550
sulfide sulfur and here is plying a

694
00:31:52,280 --> 00:31:49,590
difference between sulfate ins and

695
00:31:55,510 --> 00:31:52,290
co-existing sulfide sulfur for great

696
00:31:58,250 --> 00:31:55,520
many points throughout the akron period

697
00:32:00,980 --> 00:31:58,260
and there are dates from the succession

698
00:32:02,570 --> 00:32:00,990
of approximately 635 million years extra

699
00:32:06,530 --> 00:32:02,580
now in approximately it's very it's a

700
00:32:09,140 --> 00:32:06,540
very precise age at 635 I don't remember

701
00:32:11,240 --> 00:32:09,150
point five million years at the top of

702
00:32:13,580 --> 00:32:11,250
the glacial dynamic type and there's a

703
00:32:15,710 --> 00:32:13,590
trial zircon of approximately 621

704
00:32:18,560 --> 00:32:15,720
million years in the upper cufi

705
00:32:20,690 --> 00:32:18,570
formation and then other uranium lead

706
00:32:24,170 --> 00:32:20,700
zircon ages from ashes in the bua of

707
00:32:27,650 --> 00:32:24,180
approximately 550 million years if I can

708
00:32:28,159 --> 00:32:27,660
all I sike at all prefer to consider the

709
00:32:31,549 --> 00:32:28,169
sure

710
00:32:34,460 --> 00:32:31,559
I stope excursion here this decrease in

711
00:32:36,950 --> 00:32:34,470
inorganic carbon essentially decoupled

712
00:32:40,190 --> 00:32:36,960
from organic carbon isotopes although

713
00:32:43,249 --> 00:32:40,200

certainly there's some change but in an

714
00:32:45,830 --> 00:32:43,259
opposite direction to be related to 580

715
00:32:48,109 --> 00:32:45,840
million your gas tears event this is

716
00:32:49,729 --> 00:32:48,119
plausible though not required from the

717
00:32:51,999 --> 00:32:49,739
age constraints from the direct section

718
00:32:54,320 --> 00:32:52,009
a point i'll return to later in the talk

719
00:32:59,599 --> 00:32:54,330
fiker all suggests there are three

720
00:33:02,720 --> 00:32:59,609
stages of Han Ediacaran oxidation of the

721
00:33:06,560 --> 00:33:02,730
Earth's ocean and Atmospheric reservoirs

722
00:33:10,099 --> 00:33:06,570
in the first predominately indicated by

723
00:33:12,529 --> 00:33:10,109
the increase in Delta 34 s the

724
00:33:15,680 --> 00:33:12,539
difference between del 34 s of pyrite

725
00:33:17,570 --> 00:33:15,690
and sulfate coexisting this would seem

726
00:33:19,700 --> 00:33:17,580
to indicate growth of a sulfate

727
00:33:21,590 --> 00:33:19,710
reservoir in the ocean which is

728
00:33:25,609 --> 00:33:21,600
different than the hurricane at all cas

729
00:33:30,739 --> 00:33:25,619
low sulphate values inferred for all

730
00:33:33,259 --> 00:33:30,749
previous rocks during step two of the

731
00:33:35,180 --> 00:33:33,269
oxidation event the inorganic and

732
00:33:37,369 --> 00:33:35,190
organic reservoirs become decoupled

733
00:33:39,710 --> 00:33:37,379
there's quick oxidation of the deep do

734
00:33:42,799 --> 00:33:39,720
see reservoir similar to what's inferred

735
00:33:46,299 --> 00:33:42,809
by the somewhat quicker apparently

736
00:33:49,340 --> 00:33:46,309
although it certainly is the same event

737
00:33:51,799 --> 00:33:49,350
sure um anomaly records from the outcrop

738
00:33:54,499 --> 00:33:51,809

of leg Arun colleagues and in step 3

739
00:33:58,129 --> 00:33:54,509
bacterial sulphur disproportion further

740
00:34:00,830 --> 00:33:58,139
increases the cap Delta 34 s 2 values of

741
00:34:05,570 --> 00:34:00,840
almost 50 per mil at various parts that

742
00:34:08,510 --> 00:34:05,580
ye akron into the Cambrian the question

743
00:34:11,210 --> 00:34:08,520
is do any of these events directly

744
00:34:13,520 --> 00:34:11,220
relate to gas skiers glaciation and if

745
00:34:15,740 --> 00:34:13,530
so what is the timescale of gas tears

746
00:34:18,649 --> 00:34:15,750
deglaciation and presumed oxygenic

747
00:34:21,619 --> 00:34:18,659
increase as fike at all note the stage 1

748
00:34:24,129 --> 00:34:21,629
oxidation seemingly occurred over 25

749
00:34:26,299 --> 00:34:24,139
million years after the mara Nolan

750
00:34:29,809 --> 00:34:26,309
demonstrably low paleo latitude

751
00:34:31,909 --> 00:34:29,819
glaciation so here the sulphate increase

752
00:34:36,049 --> 00:34:31,919
which is presumed to relate to ever

753
00:34:38,329 --> 00:34:36,059
increasing Delta 34 s values spans the

754
00:34:40,850 --> 00:34:38,339
entire range of hundreds of meters of

755
00:34:45,250 --> 00:34:40,860
sig raphy up into the 620

756
00:34:48,170 --> 00:34:45,260
1 million year detrital zircon stratum

757
00:34:51,230 --> 00:34:48,180
so it's not as seemingly quick as the

758
00:34:53,750 --> 00:34:51,240
gas cures puter lee sure i'm event is

759
00:34:57,980 --> 00:34:53,760
hypothesized to be then Condon

760
00:35:00,020 --> 00:34:57,990
colleagues have noted that strictly

761
00:35:04,280 --> 00:35:00,030
speaking the sure I'm anomaly is quite

762
00:35:08,600 --> 00:35:04,290
undated anywhere between 632 million

763
00:35:10,670 --> 00:35:08,610

years in China with carbonate carbon

764
00:35:13,700 --> 00:35:10,680
isotope values in green here and

765
00:35:16,400 --> 00:35:13,710
approximately 550 1 million years where

766
00:35:18,940 --> 00:35:16,410
they see the Sherman amelie is already

767
00:35:21,830 --> 00:35:18,950
on its way back toward positive values

768
00:35:25,100 --> 00:35:21,840
here Condon colleagues prefer to

769
00:35:27,380 --> 00:35:25,110
incorporate radiometric ages of theirs

770
00:35:29,960 --> 00:35:27,390
from Newfoundland the gas skiers event

771
00:35:32,030 --> 00:35:29,970
at this point in this trigger fee partly

772
00:35:35,480 --> 00:35:32,040
based on paleontological and partly

773
00:35:37,100 --> 00:35:35,490
based on base and substance analyses but

774
00:35:40,030 --> 00:35:37,110
there's great deal wiggle room and so

775
00:35:43,400 --> 00:35:40,040
the point here is even though fight and

776
00:35:46,610 --> 00:35:43,410
Lagoon colleagues would tend to think

777
00:35:48,890 --> 00:35:46,620
that this Sherman amelie true zona sure

778
00:35:51,440 --> 00:35:48,900
wanaka nominally belongs down here at

779
00:35:53,810 --> 00:35:51,450
gas cures glaciation at the furthest at

780
00:35:56,900 --> 00:35:53,820
member it might be close to 560 million

781
00:36:00,230 --> 00:35:56,910
years and in principle it could even be

782
00:36:01,610 --> 00:36:00,240
older than 580 million years so there's

783
00:36:03,740 --> 00:36:01,620
a lot of uncertainty in the age of the

784
00:36:06,200 --> 00:36:03,750
wanaka Sherman amelie and it's direct

785
00:36:08,630 --> 00:36:06,210
correlation into any gas gear is

786
00:36:10,970 --> 00:36:08,640
glaciation since in the gas here's type

787
00:36:14,840 --> 00:36:10,980
section there are no carbonates except

788
00:36:16,880 --> 00:36:14,850

for the cap carbonate this is the end of

789
00:36:19,850 --> 00:36:16,890
part 1 of my talk and so I want to

790
00:36:21,830 --> 00:36:19,860
reiterate the exciting work that's been

791
00:36:23,840 --> 00:36:21,840
produced by these really extensive data

792
00:36:26,690 --> 00:36:23,850
sets by David fight or 1 legger ooh

793
00:36:28,870 --> 00:36:26,700
Danny laying and colleagues which is

794
00:36:31,880 --> 00:36:28,880
there's convincing association between

795
00:36:34,700 --> 00:36:31,890
glaciations and oxidation events the

796
00:36:36,980 --> 00:36:34,710
most convincing paleozoic snowball earth

797
00:36:39,080 --> 00:36:36,990
glaciation the mac mini any information

798
00:36:42,860 --> 00:36:39,090
South Africa may have been caused by an

799
00:36:45,110 --> 00:36:42,870
intern cause dramatic oxy atma version

800
00:36:47,570 --> 00:36:45,120
and Bob cop and colleagues at Caltech

801
00:36:50,900 --> 00:36:47,580
have been out frontin in enumerating

802
00:36:52,280 --> 00:36:50,910
these hypotheses and this leaves the

803
00:36:53,890 --> 00:36:52,290
question which I'm addressed in part to

804
00:36:55,690 --> 00:36:53,900
my talk just how similar

805
00:36:59,500 --> 00:36:55,700
is the paleoproterozoic and the

806
00:37:00,970 --> 00:36:59,510
neoproterozoic case and if the Paleozoic

807
00:37:03,160 --> 00:37:00,980
snow bobble is associated with first

808
00:37:06,600 --> 00:37:03,170
order a taxi at mo version what causes

809
00:37:09,340 --> 00:37:06,610
an EO pers 0 of snow water so recall

810
00:37:11,470 --> 00:37:09,350
from earlier slides the approximate time

811
00:37:15,130 --> 00:37:11,480
skills for entry and exit from

812
00:37:19,540 --> 00:37:15,140
glaciation are extremely quick based if

813
00:37:21,610 --> 00:37:19,550

nothing else on physics of how ice is

814
00:37:24,090 --> 00:37:21,620
expected to melt and ice sheets are

815
00:37:27,130 --> 00:37:24,100
expected not to stay in limbo between

816
00:37:28,720 --> 00:37:27,140
glacial and interglacial state there are

817
00:37:31,510 --> 00:37:28,730
other reasons also to suggest that

818
00:37:36,010 --> 00:37:31,520
deglaciation has been very rapid which

819
00:37:39,420 --> 00:37:36,020
I'll get to in a minute recall also from

820
00:37:41,380 --> 00:37:39,430
Halverson atolls carbon synthesis that

821
00:37:44,560 --> 00:37:41,390
immediately above the mera naam

822
00:37:46,090 --> 00:37:44,570
glaciation there is and possibly above

823
00:37:47,980 --> 00:37:46,100
the sturdy and glaciation although this

824
00:37:50,250 --> 00:37:47,990
part of the curve has been modified by

825
00:37:52,660 --> 00:37:50,260
Halverson 2007 there's a dramatic

826
00:37:55,300 --> 00:37:52,670
negative carbon isotope excursion which

827
00:37:57,730 --> 00:37:55,310
happens in short scat meters presumed to

828
00:38:00,520 --> 00:37:57,740
relate to catastrophic silicate

829
00:38:02,980 --> 00:38:00,530
weathering and rally dis distillation of

830
00:38:06,420 --> 00:38:02,990
the carbon dioxide greenhouse atmosphere

831
00:38:10,150 --> 00:38:06,430
that had built up over the snowball and

832
00:38:12,160 --> 00:38:10,160
recall again the cap carbonates often

833
00:38:14,140 --> 00:38:12,170
have unusual features for the

834
00:38:16,840 --> 00:38:14,150
successions there within associated with

835
00:38:18,660 --> 00:38:16,850
reddening the anomalous isotopes I just

836
00:38:23,590 --> 00:38:18,670
talked about in various other features

837
00:38:27,490 --> 00:38:23,600
such as giant wave ripples and this is a

838
00:38:30,130 --> 00:38:27,500

point which is difficult to

839
00:38:31,600 --> 00:38:30,140
overemphasize if you've been in the

840
00:38:34,420 --> 00:38:31,610
field and seeing some of the structures

841
00:38:36,850 --> 00:38:34,430
and cap carbonates any geologist who

842
00:38:38,800 --> 00:38:36,860
comes and and and and works on cap

843
00:38:41,760 --> 00:38:38,810
carbonates seas textures which are

844
00:38:44,440 --> 00:38:41,770
unprecedented in the rest of the pre

845
00:38:45,760 --> 00:38:44,450
which are together unprecedented

846
00:38:47,950 --> 00:38:45,770
throughout the Precambrian or

847
00:38:56,330 --> 00:38:47,960
phanerozoic record individual members

848
00:39:00,570 --> 00:38:58,830
stromatolites negative carbon isotopes

849
00:39:02,460 --> 00:39:00,580
are seen in different places but all

850
00:39:05,490 --> 00:39:02,470
together their presence immediately

851
00:39:08,100 --> 00:39:05,500
above the marin on New York rizzo

852
00:39:11,250 --> 00:39:08,110
glaciation and a decimeter even meter

853
00:39:13,440 --> 00:39:11,260
scale their sharp crested depositional

854
00:39:15,600 --> 00:39:13,450
carbonate anta forums that seemingly

855
00:39:18,420 --> 00:39:15,610
have crests which migrate back and forth

856
00:39:21,330 --> 00:39:18,430
just like a very small scale wave ripple

857
00:39:23,400 --> 00:39:21,340
in a fast flow regime Alan Hoffman

858
00:39:27,930 --> 00:39:23,410
suggests this was produced by sustained

859
00:39:32,280 --> 00:39:27,940
gale force winds time scale of days

860
00:39:34,020 --> 00:39:32,290
hours years decades suggesting that the

861
00:39:36,600 --> 00:39:34,030
whole deposition of cap carbonate was a

862
00:39:38,700 --> 00:39:36,610
similarly very quick event geochemical

863
00:39:40,710 --> 00:39:38,710

modeling also suggests the deposition

864
00:39:43,170 --> 00:39:40,720
cap carbonate occurred on time scale of

865
00:39:44,940 --> 00:39:43,180
say two thousand years plus or minus an

866
00:39:46,410 --> 00:39:44,950
order magnitude there are other fees

867
00:39:48,180 --> 00:39:46,420
like upward growing segments draped

868
00:39:50,460 --> 00:39:48,190
seafloor crystal fans which presumably

869
00:39:53,310 --> 00:39:50,470
had to outpace sedimentary to tribal

870
00:39:56,490 --> 00:39:53,320
input and other perhaps were modely

871
00:39:58,770 --> 00:39:56,500
dependent evidences lines of argument to

872
00:40:01,110 --> 00:39:58,780
suggest that the cap carbonate sequence

873
00:40:03,210 --> 00:40:01,120
that anomalous carbonate bit above the

874
00:40:07,650 --> 00:40:03,220
sluice classic New Yorkers Oaks noble

875
00:40:09,750 --> 00:40:07,660
Earth's was very rapidly deposited there

876
00:40:13,530 --> 00:40:09,760
have been two fastening recent tests of

877
00:40:15,090 --> 00:40:13,540
this and related expectations of the

878
00:40:18,150 --> 00:40:15,100
hard New Yorkers Oh snowball earth

879
00:40:19,890 --> 00:40:18,160
hypothesis the first testament is to

880
00:40:22,650 --> 00:40:19,900
prolong sea ice covering it comes from

881
00:40:27,210 --> 00:40:22,660
central Africa's lúthien art where drill

882
00:40:29,160 --> 00:40:27,220
core in Congo and Zambia of two

883
00:40:31,590 --> 00:40:29,170
successions presumed to correlate to the

884
00:40:33,990 --> 00:40:31,600
sturdy and the mera naam glaciations the

885
00:40:36,060 --> 00:40:34,000
older and the younger although the truth

886
00:40:38,550 --> 00:40:36,070
may be more complicated that near

887
00:40:40,700 --> 00:40:38,560
preserve glaciations shows dramatic

888
00:40:43,890 --> 00:40:40,710

iridium concentration and

889
00:40:47,280 --> 00:40:43,900
extraterrestrial iridium ratio profiles

890
00:40:49,760 --> 00:40:47,290
in clay stone immediately below the

891
00:40:53,820 --> 00:40:49,770
Marin Owen correlative cap carbonate and

892
00:40:57,300 --> 00:40:53,830
throughout decimeters of the lowermost

893
00:40:59,460 --> 00:40:57,310
sturdy in calcareous shale immediately

894
00:41:01,980 --> 00:40:59,470
above glacial deposit so the D glacial

895
00:41:03,540 --> 00:41:01,990
aftermath of glaciations in central

896
00:41:05,190 --> 00:41:03,550
Africa produced these shocking

897
00:41:07,710 --> 00:41:05,200
extraterrestrial iridium anomalies

898
00:41:09,790 --> 00:41:07,720
assuming these are carried by interplay

899
00:41:11,890 --> 00:41:09,800
us particles as opposed major in

900
00:41:13,960 --> 00:41:11,900
x this implies a timescale for

901
00:41:15,250 --> 00:41:13,970
accumulating iridium on the continents

902
00:41:17,740 --> 00:41:15,260
then washing them into the ocean

903
00:41:20,710 --> 00:41:17,750
afterwards of something like 12 million

904
00:41:23,470 --> 00:41:20,720
years or a quickest assuming an or

905
00:41:25,750 --> 00:41:23,480
division I r deflects say three million

906
00:41:28,750 --> 00:41:25,760
years for the duration of snowball earth

907
00:41:31,030 --> 00:41:28,760
glaciation testament to the ultra

908
00:41:36,150 --> 00:41:31,040
greenhouse escape seems to be supported

909
00:41:38,890 --> 00:41:36,160
by incredibly precise trace isotopic

910
00:41:41,740 --> 00:41:38,900
analyses of capital stone from Namibia

911
00:41:44,350 --> 00:41:41,750
in this case the presumed mera Nolan

912
00:41:46,990 --> 00:41:44,360
equivalent 636 million year old cap

913
00:41:50,260 --> 00:41:47,000

dolostone of the Kyle Berg and library

914
00:41:53,470 --> 00:41:50,270
formations in which trace concentrations

915
00:41:56,160 --> 00:41:53,480
of boron substituted for carbonate in

916
00:41:58,750 --> 00:41:56,170
the carbonate lattice show a negative

917
00:42:00,550 --> 00:41:58,760
excursion of negative nine per mil over

918
00:42:02,350 --> 00:42:00,560
two and a half meters in the cap duelist

919
00:42:03,880 --> 00:42:02,360
own before returning to their value over

920
00:42:06,370 --> 00:42:03,890
hundreds of meters of the ensuing cap

921
00:42:08,980 --> 00:42:06,380
limestone there's also decrease in

922
00:42:12,100 --> 00:42:08,990
calcium isotope composition suggesting

923
00:42:14,430 --> 00:42:12,110
together that pH of the oceans might

924
00:42:16,690 --> 00:42:14,440
have dramatically acidified since

925
00:42:20,820 --> 00:42:16,700
fractionation of boron depends on the

926
00:42:23,980 --> 00:42:20,830
speciation of borate and its associated

927
00:42:26,700 --> 00:42:23,990
complexes and seawater which is itself

928
00:42:28,840 --> 00:42:26,710
ph-dependent among other things and

929
00:42:32,290 --> 00:42:28,850
calcium isotope compositions are

930
00:42:34,480 --> 00:42:32,300
presumed to change only if you change

931
00:42:35,980 --> 00:42:34,490
the residence on a calcium by increasing

932
00:42:38,860 --> 00:42:35,990
the weathering rate from the continents

933
00:42:41,170 --> 00:42:38,870
or slowing down the sedimentary burial

934
00:42:43,090 --> 00:42:41,180
of calcium the ocean because cap

935
00:42:46,090 --> 00:42:43,100
carbonates are presumed to be fast

936
00:42:47,740 --> 00:42:46,100
deposited this indicates or this is

937
00:42:49,900 --> 00:42:47,750
hypothesized to indicate it was

938
00:42:51,850 --> 00:42:49,910

interpreted to indicate an increase in

939
00:42:55,000 --> 00:42:51,860
silicate weathering concomitant with

940
00:42:56,920 --> 00:42:55,010
ultra greenhouse high co2 acidification

941
00:43:01,320 --> 00:42:56,930
of the ocean in the immediate aftermath

942
00:43:04,420 --> 00:43:01,330
and New Yorkers Oh of snowball however

943
00:43:05,920 --> 00:43:04,430
and this gets to my particular is

944
00:43:08,440 --> 00:43:05,930
interest there have been three previous

945
00:43:11,680 --> 00:43:08,450
paleomagnetic studies that show apparent

946
00:43:15,300 --> 00:43:11,690
geomagnetic reversals within mera Nolan

947
00:43:17,500 --> 00:43:15,310
equivalent cap carbonate deposits

948
00:43:19,510 --> 00:43:17,510
firstly at all in Western Australian

949
00:43:21,730 --> 00:43:19,520
2001 and Ricardo trend dodge and

950
00:43:23,010 --> 00:43:21,740
colleagues in Brazil and Ben Kilner and

951
00:43:25,500 --> 00:43:23,020
colleagues

952
00:43:27,540 --> 00:43:25,510
from the UK working in omani successions

953
00:43:29,580 --> 00:43:27,550
if needed documented at least one

954
00:43:31,530 --> 00:43:29,590
apparent geomagnetic reversal in a cap

955
00:43:33,720 --> 00:43:31,540
carbonate but none of the studies are

956
00:43:35,280 --> 00:43:33,730
airtight for reasons not necessarily of

957
00:43:37,860 --> 00:43:35,290
the author's doing but because of

958
00:43:40,080 --> 00:43:37,870
outcrop limitations and such so the

959
00:43:42,450 --> 00:43:40,090
question is first are these indications

960
00:43:44,640 --> 00:43:42,460
reliable and second what is the

961
00:43:46,530 --> 00:43:44,650
implication through last hundred eighty

962
00:43:50,010 --> 00:43:46,540
million years geomagnetic reversals

963
00:43:52,020 --> 00:43:50,020

happen say on tens to hundreds of

964
00:43:53,430 --> 00:43:52,030
thousands or even millions of years time

965
00:43:55,170 --> 00:43:53,440
scale if there's a geomagnetic reversal

966
00:43:57,780 --> 00:43:55,180
in the cap carbonate does this mean it

967
00:44:00,540 --> 00:43:57,790
took millions of years to deposit well

968
00:44:02,580 --> 00:44:00,550
at quickest in the catan jian a peck of

969
00:44:04,950 --> 00:44:02,590
the Jurassic there were up to twenty

970
00:44:07,260 --> 00:44:04,960
geomagnetic reversals in approximately 1

971
00:44:09,060 --> 00:44:07,270
million year ammonite by ozone so what

972
00:44:11,790 --> 00:44:09,070
quickest geomagnetic reversals might

973
00:44:14,400 --> 00:44:11,800
happen at 20,000 to 50,000 your time

974
00:44:16,830 --> 00:44:14,410
scales but this is still much greater

975
00:44:20,010 --> 00:44:16,840
than the 10,000 year geochemical

976
00:44:22,560 --> 00:44:20,020
modeling or the extreme rapid deposition

977
00:44:25,980 --> 00:44:22,570
rate seemingly indicated by the climbing

978
00:44:29,490 --> 00:44:25,990
wave ripples for the hard snowball Earth

979
00:44:34,020 --> 00:44:29,500
scenario cat Billa stones so my

980
00:44:35,310 --> 00:44:34,030
investigation addresses these points and

981
00:44:37,740 --> 00:44:35,320
the thing to remember out there to

982
00:44:40,620 --> 00:44:37,750
magnetic field is it reverses episodic

983
00:44:42,540 --> 00:44:40,630
ly unpredictably the inclination the

984
00:44:44,070 --> 00:44:42,550
field varies as a function latitude from

985
00:44:45,840 --> 00:44:44,080
nearly flat with respect to Earth's

986
00:44:48,240 --> 00:44:45,850
surface of the equator nearly verbal at

987
00:44:51,990 --> 00:44:48,250
the pole and if averaged over a times

988
00:44:53,910 --> 00:44:52,000

can span of two thousand years the

989
00:44:56,550 --> 00:44:53,920
location of the apparent geomagnetic

990
00:45:00,630 --> 00:44:56,560
Pole approximates on average the true

991
00:45:03,090 --> 00:45:00,640
geocentric axial dipole in south

992
00:45:04,920 --> 00:45:03,100
australia new provoke stradder exposed

993
00:45:07,410 --> 00:45:04,930
an open fold belt which the central

994
00:45:09,150 --> 00:45:07,420
areas least metamorphose their other

995
00:45:10,650 --> 00:45:09,160
Krell ative basins throughout australian

996
00:45:12,270 --> 00:45:10,660
these have been many of the locations

997
00:45:14,340 --> 00:45:12,280
where the snowball earth hypothesis for

998
00:45:16,500 --> 00:45:14,350
the Neo berserk has been first

999
00:45:20,010 --> 00:45:16,510
elaborated by Australian Geological

1000
00:45:24,690 --> 00:45:20,020
Survey colleagues classically in the

1001
00:45:27,630 --> 00:45:24,700
1980s full tests in which magnetization

1002
00:45:31,400 --> 00:45:27,640
was shown to rap about bent bedding

1003
00:45:33,640 --> 00:45:31,410
assumed to be related to sin sedimentary

1004
00:45:36,609 --> 00:45:33,650
seismic

1005
00:45:39,309 --> 00:45:36,619
deformation within a rib might member

1006
00:45:41,230 --> 00:45:39,319
resembling glacial VAR bytes in the

1007
00:45:43,480 --> 00:45:41,240
Latin information of South Australia was

1008
00:45:45,760 --> 00:45:43,490
shown to have flat magaz a shin with

1009
00:45:48,160 --> 00:45:45,770
respect to bedding suggesting was formed

1010
00:45:50,170 --> 00:45:48,170
at the equator many authors have

1011
00:45:52,299 --> 00:45:50,180
replicated the study and others have

1012
00:45:54,339 --> 00:45:52,309
considered it suggesting that because

1013
00:45:57,490 --> 00:45:54,349

VAR White's might be very quickly

1014
00:46:02,940 --> 00:45:57,500
deposited say 60 to 20,000 years total

1015
00:46:05,049 --> 00:46:02,950
for only 10 meters of monthly couplets

1016
00:46:07,059 --> 00:46:05,059
that you might only be seeing a very

1017
00:46:08,829 --> 00:46:07,069
strange excursion election Earth's

1018
00:46:11,170 --> 00:46:08,839
magnetic field therefore the near

1019
00:46:13,660 --> 00:46:11,180
preserve glaciations might not truly be

1020
00:46:15,339 --> 00:46:13,670
little attitude Linda Solon colleagues

1021
00:46:19,329 --> 00:46:15,349
at Columbia University address this in

1022
00:46:21,190 --> 00:46:19,339
1999 where they measured systematic

1023
00:46:24,069 --> 00:46:21,200
paleomagnetic analyses throughout

1024
00:46:25,299 --> 00:46:24,079
sandstone and shale and glacial dynamic

1025
00:46:27,819 --> 00:46:25,309
tight intervals in three different

1026
00:46:29,890 --> 00:46:27,829
sections essentially producing a nearly

1027
00:46:33,660 --> 00:46:29,900
replicated magnetic polarity

1028
00:46:37,329 --> 00:46:33,670
stratigraphy also of low paleo latitude

1029
00:46:40,359 --> 00:46:37,339
so the Atlanta glaciation age unknown

1030
00:46:43,510 --> 00:46:40,369
but presume the correlate to the 635

1031
00:46:45,880 --> 00:46:43,520
million your glaciations is clearly at

1032
00:46:49,269 --> 00:46:45,890
low pehli latitude in late near perozo

1033
00:46:52,630 --> 00:46:49,279
time say seven degrees pehli latitude is

1034
00:46:54,900 --> 00:46:52,640
a good estimate I went to three sections

1035
00:46:57,039 --> 00:46:54,910
within the central undeformed part of

1036
00:46:59,589 --> 00:46:57,049
the flinders ranges of South Australia

1037
00:47:02,019 --> 00:46:59,599
where the Latin information here in this

1038
00:47:07,529 --> 00:47:02,029

dark brown color is preserved especially

1039
00:47:09,730 --> 00:47:07,539
well in the flanks of a salt diapir

1040
00:47:11,880 --> 00:47:09,740
active during the appraisal time and a

1041
00:47:14,559 --> 00:47:11,890
fourth section in the same outcrop belt

1042
00:47:16,569 --> 00:47:14,569
here eight kilometres separates a Latin

1043
00:47:19,630 --> 00:47:16,579
a creek from trees Ellen bore with the

1044
00:47:21,460 --> 00:47:19,640
recently ratified GS SP for the

1045
00:47:23,079 --> 00:47:21,470
ediacaran period and are a panorama

1046
00:47:26,019 --> 00:47:23,089
Creek in the middle and there's another

1047
00:47:27,789 --> 00:47:26,029
success section in the same outcrop belt

1048
00:47:31,029 --> 00:47:27,799
15 climbers in North appear chill in the

1049
00:47:33,490 --> 00:47:31,039
gorge this is what the rock looks like

1050
00:47:36,339 --> 00:47:33,500
here are glacial dynamic tights of lat

1051
00:47:39,970 --> 00:47:36,349
information they're red beds oh my

1052
00:47:41,309 --> 00:47:39,980
goodness I have no idea I'm a-okay here

1053
00:47:44,219 --> 00:47:41,319
we're back

1054
00:47:47,370 --> 00:47:44,229
okay here's an incisive read channelized

1055
00:47:51,299 --> 00:47:47,380
sheets and stone leading to mix Lissa

1056
00:47:54,059 --> 00:47:51,309
class to carbonate deposition showing

1057
00:47:56,189 --> 00:47:54,069
conformable gradual increase in

1058
00:47:58,079 --> 00:47:56,199
carbonate content until you reach the

1059
00:48:00,749 --> 00:47:58,089
six metre thick capital of stone at

1060
00:48:02,910 --> 00:48:00,759
latnok read the cap bill stone shows the

1061
00:48:05,699 --> 00:48:02,920
characteristic negative carbon isotope

1062
00:48:09,930 --> 00:48:05,709
anomaly and these unusual climbing wave

1063
00:48:12,029 --> 00:48:09,940

ripples rock magnetic shows that they're

1064
00:48:13,680 --> 00:48:12,039
abundant iron oxide particles these are

1065
00:48:16,559 --> 00:48:13,690
likely source from adjacent banded iron

1066
00:48:18,689 --> 00:48:16,569
formations of paleozoic age on the

1067
00:48:21,089 --> 00:48:18,699
adjacent cray times their associate with

1068
00:48:23,729 --> 00:48:21,099
clay and so the magnetism of this rock

1069
00:48:27,509 --> 00:48:23,739
is presumably adit Radel little grains

1070
00:48:29,489 --> 00:48:27,519
of Faerie magnetic hematite anti

1071
00:48:31,890 --> 00:48:29,499
ferromagnetic hematite rolling into the

1072
00:48:33,449 --> 00:48:31,900
basin and aligning on average with

1073
00:48:35,670 --> 00:48:33,459
Earth's magnetic field at the time of

1074
00:48:39,479 --> 00:48:35,680
deposition cemented into place by the

1075
00:48:42,239 --> 00:48:39,489
carbonate the magnetic records through

1076
00:48:44,729 --> 00:48:42,249
the six meters or so of cap carbon

1077
00:48:46,380 --> 00:48:44,739
Atlantic Creek are as follows there is a

1078
00:48:50,130 --> 00:48:46,390
switch not shown in this particular

1079
00:48:52,259 --> 00:48:50,140
diagram from the conformable solicit

1080
00:48:54,539 --> 00:48:52,269
classics of the uppermost Latin

1081
00:48:56,670 --> 00:48:54,549
information into the base of the cap

1082
00:48:58,890 --> 00:48:56,680
dolostone which has a certain magnetic

1083
00:49:01,140 --> 00:48:58,900
polarity here we're showing the latitude

1084
00:49:06,209 --> 00:49:01,150
and longitude respectively of the

1085
00:49:07,829 --> 00:49:06,219
computer geomagnetic Pole because it's

1086
00:49:10,109 --> 00:49:07,839
two-dimensional projection is mounting

1087
00:49:12,599 --> 00:49:10,119
equated looking at changes and then

1088
00:49:14,519 --> 00:49:12,609

there's a polarity switch about midway

1089
00:49:16,799 --> 00:49:14,529
through the cap carbonate over an

1090
00:49:18,870 --> 00:49:16,809
interval of only about 13 centimeters

1091
00:49:20,640 --> 00:49:18,880
and the rest of the cap carbonate into

1092
00:49:23,609 --> 00:49:20,650
the mix transition with overlying SaLuSa

1093
00:49:25,680 --> 00:49:23,619
plastics is of the other polarity black

1094
00:49:27,209 --> 00:49:25,690
and white represent for instance normal

1095
00:49:29,099 --> 00:49:27,219
and reverse polarities their choice is

1096
00:49:31,969 --> 00:49:29,109
somewhat arbitrary and then there's

1097
00:49:35,249 --> 00:49:31,979
another reversal back to normal polarity

1098
00:49:38,189 --> 00:49:35,259
arbitrary within the mix transition into

1099
00:49:40,620 --> 00:49:38,199
brash information solicit plastics here

1100
00:49:43,680 --> 00:49:40,630
are locations of the giant wave ripples

1101
00:49:47,099 --> 00:49:43,690
seemingly indicating fast deposition of

1102
00:49:49,229 --> 00:49:47,109
the cap carbonate the same pattern holds

1103
00:49:51,630 --> 00:49:49,239
that the Anna Rama Creek GS SP in which

1104
00:49:53,880 --> 00:49:51,640
the upper part of Latin information is

1105
00:49:54,240 --> 00:49:53,890
reversely magnetized the lower half a

1106
00:49:56,490 --> 00:49:54,250
cap

1107
00:49:58,470 --> 00:49:56,500
old stone is normally magnetized the

1108
00:50:01,110 --> 00:49:58,480
upper half of capitalist stone into

1109
00:50:03,270 --> 00:50:01,120
brashness loose elastics not cropping

1110
00:50:05,610 --> 00:50:03,280
out well here is reversely magnetized

1111
00:50:08,070 --> 00:50:05,620
and there's yet another reversal within

1112
00:50:11,550 --> 00:50:08,080
the mixed transition to overlying

1113
00:50:14,430 --> 00:50:11,560

monotonic solicit plastics this is even

1114
00:50:16,410 --> 00:50:14,440
true aight climbers north of latin creek

1115
00:50:18,240 --> 00:50:16,420
at true zona bore where the cap

1116
00:50:20,130 --> 00:50:18,250
carbonate has been attenuated only a

1117
00:50:23,090 --> 00:50:20,140
tenth of its thickness here the cap

1118
00:50:27,540 --> 00:50:23,100
karma is only 75 centimetres thick and

1119
00:50:29,430 --> 00:50:27,550
yet again the uppermost Latin ax dynamic

1120
00:50:35,040 --> 00:50:29,440
tighten sandstone faces are normally

1121
00:50:37,140 --> 00:50:35,050
magnetized a nun conformable surface and

1122
00:50:38,850 --> 00:50:37,150
sandstone associated with it locally at

1123
00:50:41,100 --> 00:50:38,860
razon de Bourgh's reversely magnetized

1124
00:50:43,650 --> 00:50:41,110
the bottom part of the cap carbonate is

1125
00:50:46,890 --> 00:50:43,660
normally magnetized and then there's a

1126
00:50:49,320 --> 00:50:46,900
transition into reverse polarity over at

1127
00:50:51,240 --> 00:50:49,330
least one sample here and you see stable

1128
00:50:53,730 --> 00:50:51,250
reverse polarity for about six samples

1129
00:50:56,160 --> 00:50:53,740
within the very top 10 or so most

1130
00:51:01,170 --> 00:50:56,170
centimeters of the 75 centimeter thick

1131
00:51:05,970 --> 00:51:01,180
Capitol summit Arizona bore all together

1132
00:51:08,100 --> 00:51:05,980
you might stretch these different

1133
00:51:09,720 --> 00:51:08,110
thickness sections at a Latin a creek

1134
00:51:11,880 --> 00:51:09,730
enter a McCree confers on board and

1135
00:51:13,380 --> 00:51:11,890
produce a composite Magnus trigger feel

1136
00:51:15,180 --> 00:51:13,390
like this different sections in

1137
00:51:18,540 --> 00:51:15,190
different colors with one meter

1138
00:51:22,590 --> 00:51:18,550

stretching factors shown for scale over

1139
00:51:26,430 --> 00:51:22,600
here the point is there's a geologically

1140
00:51:28,680 --> 00:51:26,440
stratigraphically coherent system to the

1141
00:51:31,380 --> 00:51:28,690
magnetic clarice which with in capitola

1142
00:51:33,420 --> 00:51:31,390
stone that seems to validate the

1143
00:51:36,810 --> 00:51:33,430
previous studies suggesting that really

1144
00:51:38,790 --> 00:51:36,820
is a paleo magnetic signal switch within

1145
00:51:41,310 --> 00:51:38,800
the capitalist or in fact there are

1146
00:51:43,440 --> 00:51:41,320
three geomagnetic polarity switches

1147
00:51:45,780 --> 00:51:43,450
associated with capitalist on this one

1148
00:51:48,750 --> 00:51:45,790
just below it this one just above solid

1149
00:51:51,360 --> 00:51:48,760
capitalist own so we need to ask now are

1150
00:51:53,190 --> 00:51:51,370
these truly geomagnetic reversal of a

1151
00:51:55,500 --> 00:51:53,200
normal jus dynamo in which one of these

1152
00:51:57,330 --> 00:51:55,510
polarities owns is tens or hundreds or

1153
00:52:00,330 --> 00:51:57,340
millions well tens or hundreds of

1154
00:52:02,730 --> 00:52:00,340
thousands or millions of years and can

1155
00:52:04,950 --> 00:52:02,740
we do a more precise job of quantifying

1156
00:52:07,050 --> 00:52:04,960
deposition rate here's the example

1157
00:52:08,870 --> 00:52:07,060
showing that reversal rate is very

1158
00:52:11,849 --> 00:52:08,880
uncertain

1159
00:52:14,790 --> 00:52:11,859
however the last three geomagnetic

1160
00:52:17,339 --> 00:52:14,800
reversals when studied in very high

1161
00:52:19,950 --> 00:52:17,349
deposition rate ODP I ODP cores that

1162
00:52:24,050 --> 00:52:19,960
have aged models independently drive

1163
00:52:27,150 --> 00:52:24,060

from radiometric isotopes show an

1164
00:52:29,400 --> 00:52:27,160
interesting latitude dependence from

1165
00:52:31,620 --> 00:52:29,410
sites near the equator to sites at about

1166
00:52:34,530 --> 00:52:31,630
70 degrees latitude north or south of

1167
00:52:37,620 --> 00:52:34,540
the time it takes their geomagnetic

1168
00:52:40,079 --> 00:52:37,630
field to switch from one polarity to the

1169
00:52:42,089 --> 00:52:40,089
other so it might switch erratically

1170
00:52:44,040 --> 00:52:42,099
every hundred thousand years but the

1171
00:52:45,930 --> 00:52:44,050
amount of time it takes is perhaps

1172
00:52:49,560 --> 00:52:45,940
expected to be relatively constant

1173
00:52:52,620 --> 00:52:49,570
between say ten thousand at most and two

1174
00:52:54,240 --> 00:52:52,630
thousand years at least with systematics

1175
00:52:59,970 --> 00:52:54,250
for the latitude of the site which is

1176
00:53:02,420 --> 00:52:59,980
observing that switch will return and

1177
00:53:04,140 --> 00:53:02,430
apply that to the capital stone a second

1178
00:53:05,940 --> 00:53:04,150
addressing whether these are true

1179
00:53:08,460 --> 00:53:05,950
geomagnetic reversals there are things

1180
00:53:13,320 --> 00:53:08,470
called geomagnetic excursions so here

1181
00:53:15,630 --> 00:53:13,330
example is Jim chap pilation of the last

1182
00:53:18,420 --> 00:53:15,640
two and a half million years from

1183
00:53:20,550 --> 00:53:18,430
similar high deposition rate ODP I ODP

1184
00:53:22,950 --> 00:53:20,560
cores in which within stable polarity

1185
00:53:25,349 --> 00:53:22,960
zones here's entirely normal flirty zone

1186
00:53:28,290 --> 00:53:25,359
they're very short say one to two

1187
00:53:30,089 --> 00:53:28,300
thousand year duration spikes where the

1188
00:53:32,609 --> 00:53:30,099

geomagnetic field suddenly switches

1189
00:53:36,050 --> 00:53:32,619
polarity before returning back to its

1190
00:53:39,630 --> 00:53:36,060
generally long-term stable configuration

1191
00:53:41,430 --> 00:53:39,640
the question is is this an excursion is

1192
00:53:43,200 --> 00:53:41,440
this an excursion in which case we only

1193
00:53:46,109 --> 00:53:43,210
have one or two thousand years one or

1194
00:53:48,440 --> 00:53:46,119
two thousand years somewhat more in line

1195
00:53:51,180 --> 00:53:48,450
with the fast deposition expectation I

1196
00:53:53,790 --> 00:53:51,190
would argue that it doesn't seem to be

1197
00:53:55,829 --> 00:53:53,800
the case for one thing there's adjacent

1198
00:53:57,450 --> 00:53:55,839
repetition of events there's one paleo

1199
00:53:59,550 --> 00:53:57,460
magnetic reversal in the cap carbonate

1200
00:54:03,030 --> 00:53:59,560
going from white reverse polarity to

1201
00:54:04,349 --> 00:54:03,040
black white to black a second reversal

1202
00:54:06,990 --> 00:54:04,359
and a third of Ursula at approximately

1203
00:54:10,140 --> 00:54:07,000
equivalent intervals this is different

1204
00:54:12,960 --> 00:54:10,150
from the recent record in which you have

1205
00:54:16,500 --> 00:54:12,970
these very short excursions occupying

1206
00:54:18,570 --> 00:54:16,510
otherwise long-term relative to the

1207
00:54:21,150 --> 00:54:18,580
tides and excursions stable polarity

1208
00:54:25,510 --> 00:54:23,560
secondly there are many reversals that

1209
00:54:27,700 --> 00:54:25,520
everyone accepts our true geomagnetic

1210
00:54:29,530 --> 00:54:27,710
reversals in the overlying brashness

1211
00:54:31,510 --> 00:54:29,540
list of plastics and in the Latin

1212
00:54:33,370 --> 00:54:31,520
information itself it's somewhat

1213
00:54:35,530 --> 00:54:33,380

arbitrary to consider those reversals

1214
00:54:38,980 --> 00:54:35,540
and these excursions we probably have to

1215
00:54:40,420 --> 00:54:38,990
say everything is very quick unexpected

1216
00:54:43,120 --> 00:54:40,430
switching the magnetic field or

1217
00:54:46,960 --> 00:54:43,130
everything is standard uniformitarian

1218
00:54:48,849 --> 00:54:46,970
geomagnetic and third there are is fine

1219
00:54:51,040 --> 00:54:48,859
structure within these polarities zones

1220
00:54:53,680 --> 00:54:51,050
for example in the different sections

1221
00:54:56,140 --> 00:54:53,690
there are between seven and sometimes

1222
00:54:58,570 --> 00:54:56,150
one samples recording transitional

1223
00:55:00,070 --> 00:54:58,580
directions between one polarity state

1224
00:55:03,250 --> 00:55:00,080
and the other in the middle of the cap

1225
00:55:04,570 --> 00:55:03,260
carbonate likewise you might squint and

1226
00:55:05,950 --> 00:55:04,580
say there's a transition between

1227
00:55:08,320 --> 00:55:05,960
polarities at the top of the cap

1228
00:55:11,710 --> 00:55:08,330
carbonate at the bottom and there are

1229
00:55:15,810 --> 00:55:11,720
even individual samples or sometimes two

1230
00:55:17,980 --> 00:55:15,820
or three samples here that seem to

1231
00:55:21,400 --> 00:55:17,990
excursion of one of the polarity crimes

1232
00:55:24,070 --> 00:55:21,410
to arguably here is an excursion 'old

1233
00:55:26,589 --> 00:55:24,080
erection in that case this interval of

1234
00:55:28,630 --> 00:55:26,599
ten centimeters is something like one to

1235
00:55:31,690 --> 00:55:28,640
two thousand years and this whole

1236
00:55:35,109 --> 00:55:31,700
interval is something like ten to twenty

1237
00:55:37,960 --> 00:55:35,119
or thirty thousand years curiously in

1238
00:55:40,660 --> 00:55:37,970

the best of the three other

1239
00:55:42,970 --> 00:55:40,670
paleomagnetic studies for stratigraphic

1240
00:55:44,920 --> 00:55:42,980
high resolution that ricardo trend dodge

1241
00:55:47,140 --> 00:55:44,930
and colleagues in mirasol due west cap

1242
00:55:48,880 --> 00:55:47,150
Carly Brazil their pattern is somewhat

1243
00:55:50,560 --> 00:55:48,890
similar to that found in the presumed

1244
00:55:53,050 --> 00:55:50,570
correlative knuckling a cap dolostone

1245
00:55:55,870 --> 00:55:53,060
they have one polarity which they denote

1246
00:55:58,089 --> 00:55:55,880
is reversed arbitrary in the bottom of

1247
00:56:00,099 --> 00:55:58,099
the cap dolostone switching to another

1248
00:56:01,900 --> 00:56:00,109
in the middle switching back to a

1249
00:56:04,630 --> 00:56:01,910
polarity in the top and then they have

1250
00:56:06,540 --> 00:56:04,640
very short one or two sample departures

1251
00:56:08,920 --> 00:56:06,550
from the topmost priority crime

1252
00:56:11,589 --> 00:56:08,930
superimpose on that this is somewhat

1253
00:56:13,930 --> 00:56:11,599
similar to one clear zone than the other

1254
00:56:15,910 --> 00:56:13,940
clarity than the other with some short

1255
00:56:19,540 --> 00:56:15,920
departures in the knuckle Enoch Abdullah

1256
00:56:21,700 --> 00:56:19,550
stone I've been studying so if you

1257
00:56:23,380 --> 00:56:21,710
accept the uniformitarian interpretation

1258
00:56:25,120 --> 00:56:23,390
say the capitalists own took tens of

1259
00:56:27,040 --> 00:56:25,130
thousands of years to deposit how do you

1260
00:56:28,359 --> 00:56:27,050
get around the giant wave ripples you

1261
00:56:31,120 --> 00:56:28,369
probably have to appeal to non

1262
00:56:34,060 --> 00:56:31,130
uniformitarian sedimentology microbial

1263
00:56:36,550 --> 00:56:34,070

binding of non horizontal surfaces bill

1264
00:56:40,150 --> 00:56:36,560
building nonlinearities and subsequent

1265
00:56:42,010 --> 00:56:40,160
depositional events etc I don't have an

1266
00:56:43,900 --> 00:56:42,020
answer for the crystal fans but Nora

1267
00:56:46,450 --> 00:56:43,910
crystal fans present knuckle ena or

1268
00:56:48,160 --> 00:56:46,460
mirasol cab duelist own so we haven't

1269
00:56:51,250 --> 00:56:48,170
directly constrained the deposition rate

1270
00:56:53,800 --> 00:56:51,260
of those the other parameters such as

1271
00:56:55,960 --> 00:56:53,810
hand or on Tim excuse me we're running

1272
00:56:58,090 --> 00:56:55,970
kind of long and so I was wondering can

1273
00:56:59,590 --> 00:56:58,100
you finish up and about within about

1274
00:57:02,710 --> 00:56:59,600
five to ten minutes so that we can have

1275
00:57:05,710 --> 00:57:02,720
time for questions question yep yep no

1276
00:57:07,900 --> 00:57:05,720
problem five minutes or so the carbon

1277
00:57:09,790 --> 00:57:07,910
boron and rhydian profile anomalies are

1278
00:57:13,090 --> 00:57:09,800
to some extent model dependent for

1279
00:57:15,850 --> 00:57:13,100
example the calcium isotope anomaly that

1280
00:57:18,520 --> 00:57:15,860
accompanied the boron anomaly could be

1281
00:57:20,320 --> 00:57:18,530
due to as interpreted the enhanced

1282
00:57:24,280 --> 00:57:20,330
silicate weathering or it could be a

1283
00:57:26,410 --> 00:57:24,290
result as slowed calcium burial as might

1284
00:57:29,140 --> 00:57:26,420
be expected in slow deposition rate cap

1285
00:57:32,170 --> 00:57:29,150
carbonates in terms of presumed glacier

1286
00:57:34,630 --> 00:57:32,180
usac transgressive infinity there really

1287
00:57:36,880 --> 00:57:34,640
is no easy way as i understand it for

1288
00:57:39,130 --> 00:57:36,890

general circulation models to prolong a

1289
00:57:42,720 --> 00:57:39,140
deglaciation for hundreds of thousands

1290
00:57:45,580 --> 00:57:42,730
of years we would seem to need to invoke

1291
00:57:48,160 --> 00:57:45,590
unexpected negative feedbacks like fog

1292
00:57:49,960 --> 00:57:48,170
bank cover or things like that to slow

1293
00:57:51,460 --> 00:57:49,970
down the greenhouse forcing in the

1294
00:57:55,450 --> 00:57:51,470
aftermath of the New Yorkers Oaks know

1295
00:57:57,700 --> 00:57:55,460
whether the final part of the story is

1296
00:57:59,530 --> 00:57:57,710
the knuckle ena cap carbonate paleo

1297
00:58:01,780 --> 00:57:59,540
latitude is considerably higher than

1298
00:58:04,210 --> 00:58:01,790
that of a latin information here they're

1299
00:58:06,700 --> 00:58:04,220
very late latitude was equatorial the

1300
00:58:09,340 --> 00:58:06,710
sandstone silks on latitude was somewhat

1301
00:58:10,840 --> 00:58:09,350
higher seven degrees but not Lena cap

1302
00:58:13,060 --> 00:58:10,850
carbonate latitude on an inclination

1303
00:58:15,550 --> 00:58:13,070
equal area diagram is closer to 20

1304
00:58:18,430 --> 00:58:15,560
degrees paleo latitude the pole position

1305
00:58:20,470 --> 00:58:18,440
in blue is superimposed on other poles

1306
00:58:23,290 --> 00:58:20,480
from Australia that show the final

1307
00:58:26,110 --> 00:58:23,300
mysterious possibly 9 uniformitarian

1308
00:58:29,500 --> 00:58:26,120
aspect of precambrian time dramatic

1309
00:58:33,190 --> 00:58:29,510
dispersion of seemingly robust paleo

1310
00:58:36,040 --> 00:58:33,200
magnetic poles in this case the oldest

1311
00:58:37,660 --> 00:58:36,050
of these Australian poles which are

1312
00:58:41,110 --> 00:58:37,670
listed here but aren't important for the

1313
00:58:43,530 --> 00:58:41,120

purposes of this talk is at the tail of

1314
00:58:45,990 --> 00:58:43,540
this arrow leading in

1315
00:58:49,290 --> 00:58:46,000
DD Akron time to bun rieu formation at

1316
00:58:51,720 --> 00:58:49,300
the tip of the arrow then it returns to

1317
00:58:55,650 --> 00:58:51,730
upper / de tatic information in still a

1318
00:58:58,770 --> 00:58:55,660
young ediacaran time over this tip to

1319
00:59:01,950 --> 00:58:58,780
tail the tip arrow returning to a

1320
00:59:04,140 --> 00:59:01,960
moderate relative position in this pulse

1321
00:59:05,580 --> 00:59:04,150
wife in early cambrian time and

1322
00:59:08,250 --> 00:59:05,590
continuing on to a dramatically

1323
00:59:10,440 --> 00:59:08,260
different late cambrian a parent puller

1324
00:59:12,030 --> 00:59:10,450
winder position this would seem to

1325
00:59:14,730 --> 00:59:12,040
indicate since the north pole is

1326
00:59:17,400 --> 00:59:14,740
presumed all we stay at the North

1327
00:59:20,460 --> 00:59:17,410
geomagnetic Pole that in fact Australia

1328
00:59:22,560 --> 00:59:20,470
is rotating by about 90 degrees back and

1329
00:59:25,590 --> 00:59:22,570
forth on a very quick millions of years

1330
00:59:27,780 --> 00:59:25,600
time scale Australia isn't the only

1331
00:59:29,490 --> 00:59:27,790
continent that shows this pattern the

1332
00:59:31,410 --> 00:59:29,500
best constrained global paleomagnetic

1333
00:59:33,540 --> 00:59:31,420
database for the Ediacaran period comes

1334
00:59:36,900 --> 00:59:33,550
from lorenza ancestral north america

1335
00:59:38,820 --> 00:59:36,910
we're all possibly putative ly primary

1336
00:59:42,300 --> 00:59:38,830
paleo magnetic poles are plotted in blue

1337
00:59:44,640 --> 00:59:42,310
here the most reliable and dark blue if

1338
00:59:46,440 --> 00:59:44,650

you sort these by age here's a scale

1339
00:59:48,900 --> 00:59:46,450
from purple to light purple blue to

1340
00:59:52,680 --> 00:59:48,910
green the oldest is here long range

1341
00:59:54,690 --> 00:59:52,690
dikes at 615 million years excursion to

1342
00:59:56,760 --> 00:59:54,700
pol col word apparent puller wander

1343
00:59:59,400 --> 00:59:56,770
locations coming back to equatorial

1344
01:00:01,680 --> 00:59:59,410
positions back to polar back to

1345
01:00:04,140 --> 01:00:01,690
equatorial and blue back to mid latitude

1346
01:00:06,210 --> 01:00:04,150
and back to equatorial laurentian this

1347
01:00:07,890 --> 01:00:06,220
case is moving from equator to the polo

1348
01:00:11,400 --> 01:00:07,900
player of the pole declare the pole and

1349
01:00:13,560 --> 01:00:11,410
back again as many as six times in a

1350
01:00:15,900 --> 01:00:13,570
standard pehli magnetic interpretation

1351
01:00:18,720 --> 01:00:15,910
the non-standard interpretation is that

1352
01:00:20,610 --> 01:00:18,730
this represents true polar wander if you

1353
01:00:22,470 --> 01:00:20,620
imagine bugs crawling on a surface of

1354
01:00:25,380 --> 01:00:22,480
beach ball the beach ball will start

1355
01:00:27,210 --> 01:00:25,390
rolling likewise mass anomalies imposed

1356
01:00:29,670 --> 01:00:27,220
on the surface of the planet or within

1357
01:00:33,300 --> 01:00:29,680
the interior will tend to change the

1358
01:00:34,980 --> 01:00:33,310
sting dynamics that planet for example

1359
01:00:36,660 --> 01:00:34,990
the greatest gravity anomaly in the

1360
01:00:39,420 --> 01:00:36,670
solar system the Tharsis volcanic

1361
01:00:41,940 --> 01:00:39,430
province on Mars is located precisely on

1362
01:00:45,120 --> 01:00:41,950
the Martian equator possibly as a result

1363
01:00:48,540 --> 01:00:45,130

of previous true pull or wander when we

1364
01:00:49,980 --> 01:00:48,550
go back to the glaciations which are

1365
01:00:53,100 --> 01:00:49,990
associated with these carbon isotope

1366
01:00:54,960 --> 01:00:53,110
records in the ee akron besides this 30

1367
01:00:56,000 --> 01:00:54,970
American and meringue or gas skiers

1368
01:00:58,160 --> 01:00:56,010
glaciation the

1369
01:01:00,830 --> 01:00:58,170
other dramatic carbon isotope event is

1370
01:01:04,160 --> 01:01:00,840
this bitter spring stage at about 800

1371
01:01:05,690 --> 01:01:04,170
million years the final recent exciting

1372
01:01:07,970 --> 01:01:05,700
study that's come out relating this

1373
01:01:10,850 --> 01:01:07,980
problem is that by Maloof and colleagues

1374
01:01:13,100 --> 01:01:10,860
at Princeton in which they went inside

1375
01:01:15,650 --> 01:01:13,110
carbonate platform successions of

1376
01:01:18,050 --> 01:01:15,660
Svalbard including sequence boundary

1377
01:01:21,080 --> 01:01:18,060
unconformities of unaccounted-for

1378
01:01:24,170 --> 01:01:21,090
adoration and they found the carbon

1379
01:01:25,970 --> 01:01:24,180
isotope signal here in black excursus

1380
01:01:28,790 --> 01:01:25,980
dramatically across the sequence

1381
01:01:31,790 --> 01:01:28,800
boundaries in concert with the paleo

1382
01:01:35,150 --> 01:01:31,800
magnetic signal in green note a

1383
01:01:38,510 --> 01:01:35,160
180-degree switch in flurry in magnetic

1384
01:01:41,090 --> 01:01:38,520
polarity would only move this to about

1385
01:01:43,040 --> 01:01:41,100
this location whereas the true

1386
01:01:45,950 --> 01:01:43,050
difference in pale emag declination is

1387
01:01:47,780 --> 01:01:45,960
something like 60 or 70 degrees so there

1388
01:01:49,820 --> 01:01:47,790

seems to be as dramatic change in

1389
01:01:53,300 --> 01:01:49,830
apparent plur wander coincident with

1390
01:01:56,780 --> 01:01:53,310
carbon isotope switching this is

1391
01:01:58,700 --> 01:01:56,790
suggested on this pole diagram and the

1392
01:02:00,530 --> 01:01:58,710
paleo magnetic result is very highly

1393
01:02:02,560 --> 01:02:00,540
robust since it's constrained by a sin

1394
01:02:05,060 --> 01:02:02,570
sedimentary full test remand ization

1395
01:02:08,360 --> 01:02:05,070
clusters more coherently when the fold

1396
01:02:11,210 --> 01:02:08,370
is unfolded versus when it's folded this

1397
01:02:16,300 --> 01:02:11,220
is a true 800 million year old remnant

1398
01:02:19,850 --> 01:02:16,310
direction it also indicates Haley

1399
01:02:22,070 --> 01:02:19,860
environmental things like moogle moving

1400
01:02:23,960 --> 01:02:22,080
Australia into and out of evaporate

1401
01:02:25,670 --> 01:02:23,970
belts which are consistent with the

1402
01:02:27,380 --> 01:02:25,680
geologic and stratigraphic record of

1403
01:02:29,450 --> 01:02:27,390
those basins hence the term bitter

1404
01:02:32,330 --> 01:02:29,460
springs stage for the bitter springs

1405
01:02:34,520 --> 01:02:32,340
evaporates and maloof at all model that

1406
01:02:36,890 --> 01:02:34,530
the difference carbon isotopes is due to

1407
01:02:39,260 --> 01:02:36,900
sea level fluctuations exposing and

1408
01:02:41,690 --> 01:02:39,270
introducing different reservoirs Organic

1409
01:02:43,880 --> 01:02:41,700
versus inorganic carbon if you modulate

1410
01:02:46,370 --> 01:02:43,890
the fraction of organic carbon burial

1411
01:02:48,380 --> 01:02:46,380
from about twenty to forty percent you

1412
01:02:50,690 --> 01:02:48,390
could easily produce the negative five

1413
01:02:52,850 --> 01:02:50,700

per mil shift and then positive five

1414
01:02:56,630 --> 01:02:52,860
return of the bitter springs isotope

1415
01:03:00,200 --> 01:02:56,640
stage here and here before and after the

1416
01:03:03,770 --> 01:03:00,210
two truecolor wander events so the final

1417
01:03:05,390 --> 01:03:03,780
thing that is worth saying is that's at

1418
01:03:08,060 --> 01:03:05,400
eight hundred million years but this

1419
01:03:09,230 --> 01:03:08,070
database suggesting the six times polar

1420
01:03:11,660 --> 01:03:09,240
wander switching of no

1421
01:03:14,390 --> 01:03:11,670
with America is entirely Ediacaran

1422
01:03:15,920 --> 01:03:14,400
synchronous with gas skiers glaciation

1423
01:03:19,430 --> 01:03:15,930
or spanning the same interval and

1424
01:03:21,620 --> 01:03:19,440
possibly mary nolan glaciation perhaps a

1425
01:03:23,600 --> 01:03:21,630
great many of these carbon isotope

1426
01:03:27,170 --> 01:03:23,610
anomalies just like bitter springs stage

1427
01:03:30,740 --> 01:03:27,180
are driven by true polar wander and this

1428
01:03:33,140 --> 01:03:30,750
is what drives glaciation by changing

1429
01:03:35,450 --> 01:03:33,150
global carbon cycling in the Neo purrs

1430
01:03:38,300 --> 01:03:35,460
oh just as oxy Atma version may have

1431
01:03:39,680 --> 01:03:38,310
driven it in the Paleozoic if these

1432
01:03:42,530 --> 01:03:39,690
problems are ever to be resolved we

1433
01:03:44,390 --> 01:03:42,540
needed new radiometric ages still more

1434
01:03:51,730 --> 01:03:44,400
integrated chemo stratigraphic data sets

1435
01:03:57,859 --> 01:03:55,550
and more paleo magnetic measurements to

1436
01:03:59,990 --> 01:03:57,869
tax whether true polar wander is truly

1437
01:04:02,359 --> 01:04:00,000
the the explanation for these strange

1438
01:04:04,640 --> 01:04:02,369

signals the final thing to note is that

1439
01:04:07,670 --> 01:04:04,650
the alternative to true polar wander is

1440
01:04:09,680 --> 01:04:07,680
non dipole geomagnetic fields which

1441
01:04:12,170 --> 01:04:09,690
would cast aspersion on everything

1442
01:04:15,109 --> 01:04:12,180
including the basic latitude of paleo

1443
01:04:17,180 --> 01:04:15,119
magnetic determinations from snowball

1444
01:04:19,400 --> 01:04:17,190
earth deposits to begin with so no

1445
01:04:21,349 --> 01:04:19,410
matter what we face astrobiologists in

1446
01:04:23,900 --> 01:04:21,359
the Precambrian are forced to reconcile

1447
01:04:26,300 --> 01:04:23,910
themselves with seemingly very non

1448
01:04:32,750 --> 01:04:26,310
uniformitarian processes and outcomes

1449
01:04:36,680 --> 01:04:32,760
thanks Tim thank you very much it was an

1450
01:04:38,870 --> 01:04:36,690
information loaded presentation I must

1451
01:04:40,760 --> 01:04:38,880
apologize we had some WebEx problems

1452
01:04:42,410 --> 01:04:40,770
along the way and there were at least a

1453
01:04:44,870 --> 01:04:42,420
couple of slides that we didn't think

1454
01:04:52,730 --> 01:04:44,880
clearly here I don't think that was

1455
01:05:00,039 --> 01:04:52,740
probably crossed through just like per

1456
01:05:15,559 --> 01:05:08,870
coming on our reputed thank you uh can

1457
01:05:19,880 --> 01:05:15,569
you all hear me now what's their status

1458
01:05:21,829 --> 01:05:19,890
murmur I can hear you okay uh we can

1459
01:05:23,660 --> 01:05:21,839
hear you okay I think we may have had

1460
01:05:27,710 --> 01:05:23,670
the the feedback on our end but we've

1461
01:05:29,480 --> 01:05:27,720
got it fixed uh I was going to ask one

1462
01:05:35,420 --> 01:05:29,490
quick question but let me see if anybody

1463
01:05:38,539 --> 01:05:35,430

has raised their hands on No okay first

1464
01:05:40,670 --> 01:05:38,549
of all we invite you to ask some

1465
01:05:44,809 --> 01:05:40,680
questions I will start off by asking

1466
01:05:46,730 --> 01:05:44,819
just one question about one detail early

1467
01:05:51,049 --> 01:05:46,740
in your talk that I didn't quite follow

1468
01:05:54,799 --> 01:05:51,059
you pointed to an Iridium anomaly that

1469
01:05:58,280 --> 01:05:54,809
was due you said to extraterrestrial

1470
01:06:00,230 --> 01:05:58,290
dust info wasn't quite clear why that

1471
01:06:03,829 --> 01:06:00,240
showed up as a spike if this is

1472
01:06:05,839 --> 01:06:03,839
continuous extraterrestrial dust entry

1473
01:06:11,059 --> 01:06:05,849
into the atmosphere could you explain

1474
01:06:13,010 --> 01:06:11,069
that particular point the idea about the

1475
01:06:16,069 --> 01:06:13,020
idea of bonus Alice at all is it would

1476
01:06:19,069 --> 01:06:16,079
show up as a spike only in something

1477
01:06:21,680 --> 01:06:19,079
approximating a hard snow ball state we

1478
01:06:23,690 --> 01:06:21,690
are segregating the interplanetary dust

1479
01:06:26,660 --> 01:06:23,700
reservoir which is accumulating on top

1480
01:06:29,599 --> 01:06:26,670
of the ice or on elevated Highlands from

1481
01:06:31,940 --> 01:06:29,609
the basins in which the sediment is d

1482
01:06:33,740 --> 01:06:31,950
glacially preserved so in other words if

1483
01:06:36,380 --> 01:06:33,750
there's a soft snow ball you wouldn't

1484
01:06:39,049 --> 01:06:36,390
see a spike continuous IDP flux would

1485
01:06:40,400 --> 01:06:39,059
just continuously be preserved on the

1486
01:06:42,500 --> 01:06:40,410
other hand in a hard snow while you

1487
01:06:44,240 --> 01:06:42,510
build it up and the concentration would

1488
01:06:49,500 --> 01:06:44,250

be related to the amount of time which

1489
01:06:49,510 --> 01:06:57,540
God God you thank you very much

1490
01:07:08,020 --> 01:06:59,910
we encourage you to raise your hand on

1491
01:07:16,580 --> 01:07:12,850
can we just go around take it aims no

1492
01:07:26,030 --> 01:07:19,700
are there any any further questions for

1493
01:07:31,190 --> 01:07:29,300
if that thanks for listening well Jim

1494
01:07:44,020 --> 01:07:31,200
thank you very much we appreciate that

1495
01:07:50,690 --> 01:07:47,510
the high values from Indiana I had

1496
01:07:52,190 --> 01:07:50,700
actually two questions first was I

1497
01:07:55,400 --> 01:07:52,200
didn't quite understand what was the

1498
01:07:59,410 --> 01:07:55,410
effect of polar wound around the carbon

1499
01:08:04,070 --> 01:07:59,420
isotopes in the sediments so that's one

1500
01:08:07,360 --> 01:08:04,080
and another one is you said that the

1501
01:08:10,910 --> 01:08:07,370
switching of the orientation of the

1502
01:08:13,820 --> 01:08:10,920
poles from north to south and south soft

1503
01:08:17,570 --> 01:08:13,830
North takes about two thousand years to

1504
01:08:20,030 --> 01:08:17,580
210 from one to about 10,000 years the

1505
01:08:23,780 --> 01:08:20,040
switching period so how that period

1506
01:08:26,780 --> 01:08:23,790
affect the the biota living on the

1507
01:08:29,960 --> 01:08:26,790
surface is it any effect on the UV

1508
01:08:33,530 --> 01:08:29,970
radiation affecting the life on the

1509
01:08:38,110 --> 01:08:33,540
surface to more extent during that

1510
01:08:40,670 --> 01:08:38,120
switching period thank you the answer is

1511
01:08:43,550 --> 01:08:40,680
we answer the second question is is

1512
01:08:46,340 --> 01:08:43,560
quickly dealt with and I'll be brief on

1513
01:08:47,930 --> 01:08:46,350

the first two yes during a switch from

1514
01:08:50,300 --> 01:08:47,940
one clearly state to the other the

1515
01:08:52,970 --> 01:08:50,310
geomagnetic field strength does go down

1516
01:08:54,740 --> 01:08:52,980
in all observed phanerozoic records

1517
01:08:57,200 --> 01:08:54,750
presumably that allows greater

1518
01:08:59,480 --> 01:08:57,210
penetration of ultraviolet light being

1519
01:09:01,309 --> 01:08:59,490
the more mutations and so forth but

1520
01:09:03,500 --> 01:09:01,319
whether that has any cumulative effect

1521
01:09:05,750 --> 01:09:03,510
on by Otis is really uncertain and

1522
01:09:08,780 --> 01:09:05,760
certainly at this stage most of the

1523
01:09:11,150 --> 01:09:08,790
biota are marine microorganisms in which

1524
01:09:13,880 --> 01:09:11,160
case the penetration of ultraviolet

1525
01:09:15,920 --> 01:09:13,890
light into seawater is somewhat

1526
01:09:19,130 --> 01:09:15,930
different than say a land-based organism

1527
01:09:22,039 --> 01:09:19,140
would be in terms of true polar

1528
01:09:24,620 --> 01:09:22,049
wandering carbon isotopes because earth

1529
01:09:27,110 --> 01:09:24,630
is not perfectly solid its viscous

1530
01:09:30,320 --> 01:09:27,120
inside as it spins there's a spin bulge

1531
01:09:33,260 --> 01:09:30,330
and because angular momentum must always

1532
01:09:36,230 --> 01:09:33,270
be conserved during true polar wander

1533
01:09:38,990 --> 01:09:36,240
which is basically slip of the whole

1534
01:09:41,120 --> 01:09:39,000
solid earth the mantle and crust on

1535
01:09:43,670 --> 01:09:41,130
top of the core-mantle boundary so it's

1536
01:09:46,340 --> 01:09:43,680
slip on that core-mantle boundary the

1537
01:09:48,289 --> 01:09:46,350
earth is still spinning in the same way

1538
01:09:50,720 --> 01:09:48,299

it was before troop Allah wander ever

1539
01:09:52,450 --> 01:09:50,730
happened what that means is the spin

1540
01:09:55,190 --> 01:09:52,460
bulbs that used to be on the equator

1541
01:09:59,660 --> 01:09:55,200
slips on the core-mantle boundary and

1542
01:10:03,200 --> 01:09:59,670
tends to itinerant ly no longer be

1543
01:10:06,050 --> 01:10:03,210
equatorial so the mantle flows and

1544
01:10:09,770 --> 01:10:06,060
relaxes to create the spin bold once

1545
01:10:12,470 --> 01:10:09,780
more equatorial because water is so much

1546
01:10:14,630 --> 01:10:12,480
less viscous than mantle material the

1547
01:10:17,270 --> 01:10:14,640
oceans can adjust to the spin bulge

1548
01:10:20,000 --> 01:10:17,280
moving itinerant ly much quicker than

1549
01:10:22,190 --> 01:10:20,010
the mantle can hence during tupelo

1550
01:10:24,770 --> 01:10:22,200
wander you see regression in two

1551
01:10:28,280 --> 01:10:24,780
quadrants of the earth two opposite

1552
01:10:30,260 --> 01:10:28,290
projects here and here and you see

1553
01:10:32,510 --> 01:10:30,270
transgression and the other two

1554
01:10:36,950 --> 01:10:32,520
quadrants city or those that the spin

1555
01:10:42,200 --> 01:10:36,960
bulge is moving away from so spin bold

1556
01:10:44,230 --> 01:10:42,210
moves toward it quadrant you get sea

1557
01:10:47,330 --> 01:10:44,240
level drop away from its sea level rise

1558
01:10:50,330 --> 01:10:47,340
the adidas seal the drop and rise of 100

1559
01:10:52,610 --> 01:10:50,340
meter scale will tend to destabilize

1560
01:10:55,910 --> 01:10:52,620
methane clathrates that are on the shelf

1561
01:10:58,670 --> 01:10:55,920
it'll expose previously buried organic

1562
01:11:00,740 --> 01:10:58,680
carbon to remineralization it might

1563
01:11:02,750 --> 01:11:00,750

change the riverine and atmospheric

1564
01:11:06,080 --> 01:11:02,760
circulation or rain patterns so you're

1565
01:11:08,030 --> 01:11:06,090
bringing nutrients to different ocean

1566
01:11:10,520 --> 01:11:08,040
basins and you're changing carbon burial

1567
01:11:13,000 --> 01:11:10,530
systematics it could modulate a whole

1568
01:11:17,270 --> 01:11:13,010
variety of carbon cycle systematics and

1569
01:11:19,340 --> 01:11:17,280
so maloof at all simply note that the

1570
01:11:21,770 --> 01:11:19,350
magnitude of change it would take would

1571
01:11:24,110 --> 01:11:21,780
be twenty percent change in fraction of

1572
01:11:27,230 --> 01:11:24,120
organic carbon burial they don't say

1573
01:11:28,640 --> 01:11:27,240
precisely where that enhanced carbon

1574
01:11:35,920 --> 01:11:28,650
burial would be but it's presumably

1575
01:11:42,660 --> 01:11:38,570
thank you

1576
01:11:42,670 --> 01:11:53,220
we have a question of Goddard

1577
01:11:53,230 --> 01:11:58,620
goddard would you go ahead please

1578
01:12:04,729 --> 01:12:00,950
there's no

1579
01:12:07,490 --> 01:12:04,739
I can hear you now okay this is my

1580
01:12:09,860 --> 01:12:07,500
goomah would you tell us a little more

1581
01:12:15,110 --> 01:12:09,870
about why you think that a polarity

1582
01:12:18,860 --> 01:12:15,120
reversal could influence biota on earth

1583
01:12:21,500 --> 01:12:18,870
I realized that lack of magnetic field

1584
01:12:24,470 --> 01:12:21,510
permits the solar wind to penetrate into

1585
01:12:26,420 --> 01:12:24,480
the upper atmosphere but it's not clear

1586
01:12:29,870 --> 01:12:26,430
to me why that would causally affect

1587
01:12:33,620 --> 01:12:29,880
life at the surface of the earth or

1588
01:12:35,959 --> 01:12:33,630

below in a particular in order to change

1589
01:12:38,390 --> 01:12:35,969
the UV flux at the surface of the earth

1590
01:12:41,150 --> 01:12:38,400
you have to change the ozone column

1591
01:12:43,640 --> 01:12:41,160
density in the stratosphere so perhaps

1592
01:12:46,370 --> 01:12:43,650
you could clarify how that changes as a

1593
01:12:52,340 --> 01:12:46,380
result of the production and hang on the

1594
01:12:54,650 --> 01:12:52,350
field strength well I've slightly

1595
01:12:56,510 --> 01:12:54,660
miscommunicate I quite agree with you I

1596
01:12:58,250 --> 01:12:56,520
don't expect geomagnetic field

1597
01:13:01,340 --> 01:12:58,260
transitions to have any measurable

1598
01:13:04,910 --> 01:13:01,350
effect on biota if they did it would

1599
01:13:06,440 --> 01:13:04,920
presumably be a response to decrease to

1600
01:13:08,990 --> 01:13:06,450
your magnetic intensity and you would be

1601
01:13:11,120 --> 01:13:09,000
limited to modeling precisely the

1602
01:13:14,060 --> 01:13:11,130
processes you just you just see numerate

1603
01:13:17,270 --> 01:13:14,070
but in any sort of sense where that

1604
01:13:20,240 --> 01:13:17,280
leaves the record I most be most geomag

1605
01:13:23,360 --> 01:13:20,250
diskin Syria quite unlikely yeah

1606
01:13:27,080 --> 01:13:23,370
actually that's what I was hoping you

1607
01:13:29,090 --> 01:13:27,090
would say it turns out that I've been

1608
01:13:32,390 --> 01:13:29,100
sitting here thinking about the physics

1609
01:13:34,370 --> 01:13:32,400
and one of the things that might happen

1610
01:13:36,229 --> 01:13:34,380
as a result of the reduction of field

1611
01:13:39,500 --> 01:13:36,239
intensity is the solar wind then does

1612
01:13:41,870 --> 01:13:39,510
strike the upper atmosphere and what

1613
01:13:45,380 --> 01:13:41,880

that does is it creates a much more

1614
01:13:48,500 --> 01:13:45,390
intense x-ray flux this is actually

1615
01:13:50,770 --> 01:13:48,510
observed at Mars for example the x-rays

1616
01:13:53,030 --> 01:13:50,780
have the property that they can

1617
01:13:55,700 --> 01:13:53,040
penetrate about 10 grams per square

1618
01:13:58,670 --> 01:13:55,710
centimeter material until they interact

1619
01:14:02,030 --> 01:13:58,680
and produce a ten killable photoelectron

1620
01:14:05,090 --> 01:14:02,040
that happens to occur at earth

1621
01:14:07,729 --> 01:14:05,100
stratospheric level and that's just

1622
01:14:09,860 --> 01:14:07,739
where the ozone layer resides and so it

1623
01:14:11,959 --> 01:14:09,870
seems to me that there is what looking

1624
01:14:13,600 --> 01:14:11,969
at the prospect of whether in fact this

1625
01:14:16,340 --> 01:14:13,610
changed

1626
01:14:19,910 --> 01:14:16,350
infusion of energetic electrons could in

1627
01:14:24,730 --> 01:14:19,920
fact affect the ozone column density and

1628
01:14:30,640 --> 01:14:24,740
thereby you can i or of the earth or

1629
01:14:35,510 --> 01:14:33,320
molecules that react in the ozone

1630
01:14:37,550 --> 01:14:35,520
reaction series but but I agree what you

1631
01:14:40,100 --> 01:14:37,560
said is is a is the sort of mechanism

1632
01:14:42,260 --> 01:14:40,110
you would have to pursue if you wanted

1633
01:14:45,370 --> 01:14:42,270
to construct that sort of thing but I

1634
01:14:48,080 --> 01:14:45,380
don't think it's very relevant to

1635
01:14:50,390 --> 01:14:48,090
neoproterozoic or paleozoic biota

1636
01:14:52,490 --> 01:14:50,400
although in a general sense it's a

1637
01:14:54,860 --> 01:14:52,500
question that people always ask when you

1638
01:14:55,970 --> 01:14:54,870

talk about geomagnetic reversals I don't

1639
01:14:59,200 --> 01:14:55,980
think anybody's thought about this

1640
01:15:03,140 --> 01:14:59,210
particular mechanism well thanks a lot

1641
01:15:11,339 --> 01:15:03,150
interesting thanks I'll I might email

1642
01:15:20,799 --> 01:15:13,839
okay it sounds like there are no further

1643
01:15:23,439 --> 01:15:20,809
questions going once going twice well in

1644
01:15:26,020 --> 01:15:23,449
that case Tim thank you for a very

1645
01:15:29,919 --> 01:15:26,030
information rich and interesting seminar

1646
01:15:33,209 --> 01:15:29,929
and we will see you all in about a month