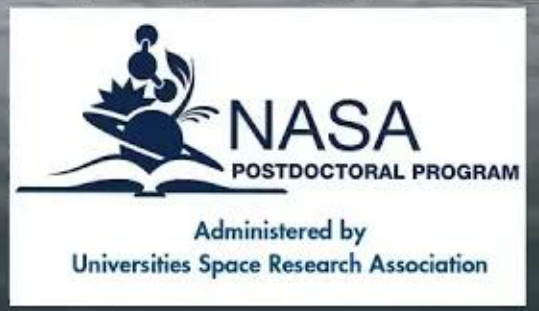
Supercontinent break-ups as drivers for Proterozoic oxygenation events and carbon isotope excursions

James Eguchi*, Charles Diamond, Timothy Lyons

University of California Riverside – Dept. of Earth and Planetary Sciences

*eguchi.james@gmail.com

UC RIVERSIDE



1
00:00:07,829 --> 00:00:06,150
carbon and oxygen

2
00:00:09,430 --> 00:00:07,839
are two elements which are critical to

3
00:00:11,190 --> 00:00:09,440
supporting life

4
00:00:14,390 --> 00:00:11,200
and these two elements are intimately

5
00:00:16,310 --> 00:00:14,400
linked by the process of photosynthesis

6
00:00:18,150 --> 00:00:16,320
this relationship is also evident in the

7
00:00:19,750 --> 00:00:18,160
geologic record

8
00:00:22,230 --> 00:00:19,760
in these two figures i'm showing the

9
00:00:24,070 --> 00:00:22,240
delta 13c of marine carbonates and

10
00:00:26,230 --> 00:00:24,080
atmospheric oxygen levels for the last

11
00:00:28,630 --> 00:00:26,240
three and a half billion years

12
00:00:30,070 --> 00:00:28,640
delta 13c is essentially the ratio of

13
00:00:33,350 --> 00:00:30,080

carbon 13 to carbon

14
00:00:36,630 --> 00:00:33,360
12 with more carbon 13 resulting in the

15
00:00:38,310 --> 00:00:36,640
in higher delta 13c when we look at the

16
00:00:40,389 --> 00:00:38,320
oxygen curve through time we can see

17
00:00:41,910 --> 00:00:40,399
that atmospheric oxygen rises in two

18
00:00:44,470 --> 00:00:41,920
major steps

19
00:00:45,990 --> 00:00:44,480
first in the paleo during what is called

20
00:00:47,389 --> 00:00:46,000
the great oxidation event

21
00:00:49,990 --> 00:00:47,399
and a second time during the

22
00:00:53,350 --> 00:00:50,000
neoproterozoic during what is called

23
00:00:55,590 --> 00:00:53,360
the neoprotozoic oxygenation event

24
00:00:57,189 --> 00:00:55,600
this figure shows that these major

25
00:00:59,510 --> 00:00:57,199
oxygenation events

26
00:01:01,830 --> 00:00:59,520
coincide with positive carbon isotope

27
00:01:04,390 --> 00:01:01,840
excursions in marine carbonates

28
00:01:06,710 --> 00:01:04,400
when we look at the delta 13c curve we

29
00:01:09,190 --> 00:01:06,720
can see that for most of earth history

30
00:01:10,149 --> 00:01:09,200
delta 13c has a baseline of around zero

31
00:01:13,030 --> 00:01:10,159
per ml

32
00:01:15,749 --> 00:01:13,040
so whenever delta 13c deviates from zero

33
00:01:18,149 --> 00:01:15,759
we call it carbon isotope excursion

34
00:01:21,109 --> 00:01:18,159
there is a reason to explain why

35
00:01:23,030 --> 00:01:21,119
increases in atmospheric oxygen

36
00:01:25,749 --> 00:01:23,040
are accompanied by positive carbon

37
00:01:28,870 --> 00:01:25,759
isotope excursions

38
00:01:30,710 --> 00:01:28,880

co2 is removed in two forms inorganic

39
00:01:31,670 --> 00:01:30,720
carbonate which has a relatively high

40
00:01:34,149 --> 00:01:31,680
delta 13c

41
00:01:35,910 --> 00:01:34,159
of around 0 per ml and organic carbon

42
00:01:39,030 --> 00:01:35,920
which has a low delta 13c

43
00:01:41,749 --> 00:01:39,040
around -25 per mil the ratio

44
00:01:43,030 --> 00:01:41,759
of total carbon that is buried as

45
00:01:46,069 --> 00:01:43,040
organic carbon is called

46
00:01:48,630 --> 00:01:46,079
f org and when f org increases

47
00:01:50,149 --> 00:01:48,640
more carbon is buried as organic carbon

48
00:01:51,830 --> 00:01:50,159
which raises oxygen

49
00:01:53,270 --> 00:01:51,840
due to the burial of photosynthetic

50
00:01:55,510 --> 00:01:53,280
products

51
00:01:57,670 --> 00:01:55,520
increases in f org also increase the

52
00:02:00,389 --> 00:01:57,680
delta 13c of marine carbonates

53
00:02:02,149 --> 00:02:00,399
because organic carbon is preferentially

54
00:02:03,270 --> 00:02:02,159
organic carbon preferentially takes up

55
00:02:08,389 --> 00:02:03,280
carbon 12

56
00:02:10,389 --> 00:02:08,399
in the carbon pool from which marine

57
00:02:13,110 --> 00:02:10,399
carbonates form

58
00:02:15,110 --> 00:02:13,120
so increased f org is one possible neck

59
00:02:16,790 --> 00:02:15,120
mechanism to drive the coupled increase

60
00:02:18,550 --> 00:02:16,800
of atmospheric oxygen

61
00:02:22,229 --> 00:02:18,560
and the positive carbon isotope

62
00:02:24,229 --> 00:02:22,239
excursions observed in the proterozoic

63
00:02:25,270 --> 00:02:24,239

and while the mechanism of increased f

64
00:02:27,110 --> 00:02:25,280
org

65
00:02:28,470 --> 00:02:27,120
driving positive carbon isotope

66
00:02:30,790 --> 00:02:28,480
excursions

67
00:02:31,670 --> 00:02:30,800
and oxygenation events is scientifically

68
00:02:33,030 --> 00:02:31,680
sound

69
00:02:35,030 --> 00:02:33,040
some research has brought it into

70
00:02:36,869 --> 00:02:35,040
question for one

71
00:02:39,350 --> 00:02:36,879
some studies have shown that oxygen may

72
00:02:41,110 --> 00:02:39,360
have begun to rise prior to the onset of

73
00:02:43,030 --> 00:02:41,120
the carbonite stop excursion

74
00:02:45,350 --> 00:02:43,040
making it difficult to explain both

75
00:02:47,430 --> 00:02:45,360
events with increased effort

76
00:02:49,110 --> 00:02:47,440
additionally these positive carbon

77
00:02:50,630 --> 00:02:49,120
isotope excursions are extremely

78
00:02:52,070 --> 00:02:50,640
long-lived

79
00:02:54,309 --> 00:02:52,080
lasting for hundreds of millions of

80
00:02:56,790 --> 00:02:54,319
years and it has been difficult to

81
00:03:00,070 --> 00:02:56,800
provide any biological mechanisms

82
00:03:01,830 --> 00:03:00,080
to sustain increased f-org for such long

83
00:03:03,430 --> 00:03:01,840
periods of times

84
00:03:05,670 --> 00:03:03,440
time scales of hundreds of millions of

85
00:03:07,270 --> 00:03:05,680
years align better with processes

86
00:03:09,670 --> 00:03:07,280
occurring in the mantel's deep carbon

87
00:03:12,149 --> 00:03:09,680
cycle and are on the same magnitude

88
00:03:13,509 --> 00:03:12,159

mantle overturn times so for the rest of

89
00:03:15,670 --> 00:03:13,519
the presentation

90
00:03:18,229 --> 00:03:15,680
i'll be talking about a model which uses

91
00:03:19,910 --> 00:03:18,239
carbon cycle processing

92
00:03:22,390 --> 00:03:19,920
occurring in the mantle to explain the

93
00:03:25,750 --> 00:03:22,400
co-evolution of carbon and oxygen

94
00:03:27,030 --> 00:03:25,760
at earth's surface so here i'll talk

95
00:03:30,789 --> 00:03:27,040
about how we can increase

96
00:03:33,030 --> 00:03:30,799
oxygen with no carbon isotope excursion

97
00:03:34,710 --> 00:03:33,040
so the main process that controls the

98
00:03:36,869 --> 00:03:34,720
flux of carbonate production is the

99
00:03:39,030 --> 00:03:36,879
weathering of continental rocks

100
00:03:41,030 --> 00:03:39,040
which deliver cations such as calcium

101
00:03:42,869 --> 00:03:41,040
and magnesium to the oceans

102
00:03:44,789 --> 00:03:42,879
which stimulates the precipitation of

103
00:03:46,550 --> 00:03:44,799
carbonates

104
00:03:48,070 --> 00:03:46,560
this weathering flux is sensitive to

105
00:03:50,710 --> 00:03:48,080
atmospheric co2

106
00:03:51,910 --> 00:03:50,720
and the weather ability of rocks which

107
00:03:54,949 --> 00:03:51,920
is controlled by

108
00:03:57,750 --> 00:03:54,959
composition land area and precipitation

109
00:03:59,270 --> 00:03:57,760
among other things so if the weathering

110
00:04:01,110 --> 00:03:59,280
flux increases

111
00:04:02,630 --> 00:04:01,120
the carbonate production flush also

112
00:04:04,869 --> 00:04:02,640
increases

113
00:04:06,070 --> 00:04:04,879

the production flux the production of

114
00:04:08,229 --> 00:04:06,080
organic carbon

115
00:04:09,670 --> 00:04:08,239
is also controlled by nutrients such as

116
00:04:11,589 --> 00:04:09,680
phosphorus which are derived from

117
00:04:17,430 --> 00:04:11,599
continental weathering

118
00:04:19,270 --> 00:04:17,440
can increase production of both

119
00:04:20,949 --> 00:04:19,280
carbonate and organic carbon

120
00:04:22,469 --> 00:04:20,959
and if they increase proportionally then

121
00:04:25,030 --> 00:04:22,479
there's no change in f

122
00:04:25,990 --> 00:04:25,040
org to accompany the increased burial of

123
00:04:28,469 --> 00:04:26,000
organic carbon

124
00:04:29,990 --> 00:04:28,479
and rise in atmospheric oxygen

125
00:04:32,469 --> 00:04:30,000
subsequently

126
00:04:34,310 --> 00:04:32,479
organic carbon and carbonate are buried

127
00:04:35,350 --> 00:04:34,320
on the seafloor and subducted deep into

128
00:04:37,110 --> 00:04:35,360
the mantle

129
00:04:40,629 --> 00:04:37,120
which is where we propose the carbon

130
00:04:43,030 --> 00:04:40,639
isotope excursion originates

131
00:04:44,710 --> 00:04:43,040
so after being subjected to the elevated

132
00:04:46,469 --> 00:04:44,720
temperatures in the mantle

133
00:04:48,550 --> 00:04:46,479
organic carbon will metamorphose to

134
00:04:50,310 --> 00:04:48,560
graphite so here i show

135
00:04:52,629 --> 00:04:50,320
how graphite and carbonate behave

136
00:04:54,710 --> 00:04:52,639
differently in the mantle

137
00:04:56,710 --> 00:04:54,720
this figure on the right shows how much

138
00:04:58,230 --> 00:04:56,720

of the originally subducted organic

139
00:05:00,070 --> 00:04:58,240
carbon

140
00:05:01,830 --> 00:05:00,080
how much of the originally subducted

141
00:05:02,310 --> 00:05:01,840
carbon will remain in this abducting

142
00:05:04,230 --> 00:05:02,320
slab

143
00:05:06,310 --> 00:05:04,240
as a function of pressure which can be

144
00:05:09,350 --> 00:05:06,320
thought of as how deep the slab has

145
00:05:09,990 --> 00:05:09,360
subducted into the mantle this figure is

146
00:05:12,150 --> 00:05:10,000
generated from

147
00:05:13,990 --> 00:05:12,160
high pressure experiments conducted on

148
00:05:15,270 --> 00:05:14,000
graphite and carbonate under mantle

149
00:05:18,150 --> 00:05:15,280
conditions

150
00:05:19,749 --> 00:05:18,160
the black curve shows graphite retention

151
00:05:21,749 --> 00:05:19,759
while the red and blue curves show

152
00:05:24,310 --> 00:05:21,759
carbonate retention

153
00:05:25,990 --> 00:05:24,320
this figure shows that carbonate is more

154
00:05:28,390 --> 00:05:26,000
efficiently released from subducting

155
00:05:30,310 --> 00:05:28,400
slabs compared to graphite

156
00:05:31,830 --> 00:05:30,320
and what this means is that carbonates

157
00:05:33,590 --> 00:05:31,840
subducted into the mantle

158
00:05:35,430 --> 00:05:33,600
are more easily recycled back to the

159
00:05:37,510 --> 00:05:35,440
surface compared to graphite

160
00:05:39,670 --> 00:05:37,520
which opens up the possibility of

161
00:05:40,950 --> 00:05:39,680
driving carbon isotope excursions by

162
00:05:44,310 --> 00:05:40,960
fractioning graphite

163
00:05:45,749 --> 00:05:44,320

and carbonate in the mantle so here's a

164
00:05:47,749 --> 00:05:45,759
schematic diagram

165
00:05:50,230 --> 00:05:47,759
to outline the mechanisms for driving

166
00:05:52,150 --> 00:05:50,240
carbon isotope excursions by deep carbon

167
00:05:54,310 --> 00:05:52,160
cycle processes

168
00:05:56,469 --> 00:05:54,320
this shows a cross section of the earth

169
00:05:59,510 --> 00:05:56,479
with three different volcanic centers

170
00:06:00,710 --> 00:05:59,520
mid-ocean ridges arc volcanoes which

171
00:06:02,629 --> 00:06:00,720
receive

172
00:06:04,710 --> 00:06:02,639
significant contributions from materials

173
00:06:06,550 --> 00:06:04,720
removed from the subducting slab

174
00:06:08,550 --> 00:06:06,560
and ocean island volcanoes which are

175
00:06:09,510 --> 00:06:08,560
thought to be fed by upwelling mantle

176
00:06:11,990 --> 00:06:09,520
plumes

177
00:06:12,710 --> 00:06:12,000
which carry material from the deep

178
00:06:16,790 --> 00:06:12,720
mantle

179
00:06:20,230 --> 00:06:16,800
and often contain subducted slabs

180
00:06:22,390 --> 00:06:20,240
mid-ocean ridges are are mostly sourced

181
00:06:24,390 --> 00:06:22,400
from depleted upper mantle

182
00:06:27,350 --> 00:06:24,400
and this is thought to contain mostly

183
00:06:30,390 --> 00:06:27,360
primordial carbon which has a delta 13c

184
00:06:32,070 --> 00:06:30,400
of around -5 per ml and most previous

185
00:06:33,350 --> 00:06:32,080
research has used this value of around

186
00:06:35,909 --> 00:06:33,360
minus 5 per ml

187
00:06:38,309 --> 00:06:35,919
for all volcanically emitted co2 and

188
00:06:41,110 --> 00:06:38,319

assume that this value never changes

189
00:06:42,629 --> 00:06:41,120
however this may not be the case as

190
00:06:44,710 --> 00:06:42,639
shown in the previous slide

191
00:06:46,710 --> 00:06:44,720
at sub-bar conditions carbonate is more

192
00:06:48,550 --> 00:06:46,720
easily removed from the subducting slab

193
00:06:50,870 --> 00:06:48,560
compared to graphite

194
00:06:52,629 --> 00:06:50,880
therefore arc volcanoes are likely to be

195
00:06:56,070 --> 00:06:52,639
enriched in carbonate derived

196
00:06:59,270 --> 00:06:56,080
co2 which has a delta 13c

197
00:07:01,670 --> 00:06:59,280
of around zero per ml therefore arc co2

198
00:07:04,390 --> 00:07:01,680
is likely to have delta 13c

199
00:07:06,070 --> 00:07:04,400
greater than minus 5 per ml so if the

200
00:07:08,710 --> 00:07:06,080
arc flux increases

201
00:07:09,350 --> 00:07:08,720
then the delta 13c of global co2

202
00:07:11,430 --> 00:07:09,360
emissions

203
00:07:14,150 --> 00:07:11,440
will increase and initiate a positive

204
00:07:16,950 --> 00:07:14,160
carbon isotope excursion

205
00:07:18,469 --> 00:07:16,960
now after subducting past subarc depths

206
00:07:19,430 --> 00:07:18,479
slab will have lost most of its

207
00:07:21,430 --> 00:07:19,440
carbonate

208
00:07:22,550 --> 00:07:21,440
and now will be relatively enriched in

209
00:07:26,469 --> 00:07:22,560
gravitized organic

210
00:07:28,150 --> 00:07:26,479
carbon these deeply subducted slabs may

211
00:07:29,270 --> 00:07:28,160
then become entrained in upwelling

212
00:07:30,710 --> 00:07:29,280
mantle plumes

213
00:07:32,710 --> 00:07:30,720

and contributes to ocean island

214
00:07:34,150 --> 00:07:32,720
volcanism releasing the subducted

215
00:07:35,990 --> 00:07:34,160
organic carbon

216
00:07:37,990 --> 00:07:36,000
this will result in a spike of co2

217
00:07:40,950 --> 00:07:38,000
emissions with delta 13c

218
00:07:43,270 --> 00:07:40,960
less than minus 5 per ml and this will

219
00:07:44,230 --> 00:07:43,280
decrease the delta 13c of global co2

220
00:07:46,230 --> 00:07:44,240
emissions

221
00:07:47,350 --> 00:07:46,240
and will terminate the positive carbon

222
00:07:49,189 --> 00:07:47,360
isotope excursion

223
00:07:52,629 --> 00:07:49,199
and possibly even drive a negative

224
00:07:56,390 --> 00:07:53,909
so now that i have outlined the

225
00:07:57,990 --> 00:07:56,400
mechanism for driving carbon

226
00:07:59,670 --> 00:07:58,000
carbon isotope excursions via deep

227
00:08:01,749 --> 00:07:59,680
carbon cycling i want to share some

228
00:08:03,589 --> 00:08:01,759
results from a box model we developed

229
00:08:05,830 --> 00:08:03,599
to account for these behaviors of carbon

230
00:08:07,430 --> 00:08:05,840
in the mantle i won't go into too much

231
00:08:09,510 --> 00:08:07,440
detail on all the flux and

232
00:08:11,589 --> 00:08:09,520
fluxes and reservoirs in the man in the

233
00:08:12,070 --> 00:08:11,599
model but i will outline some of the

234
00:08:13,749 --> 00:08:12,080
more

235
00:08:15,270 --> 00:08:13,759
some of the important assumptions of the

236
00:08:17,110 --> 00:08:15,280
model first

237
00:08:18,790 --> 00:08:17,120
the carbonate burial flux is controlled

238
00:08:21,830 --> 00:08:18,800

by the equation

239
00:08:23,270 --> 00:08:21,840
k times co2 to the nth power where k is

240
00:08:25,189 --> 00:08:23,280
a variable which accounts for how

241
00:08:27,749 --> 00:08:25,199
weatherable the continents are

242
00:08:29,749 --> 00:08:27,759
and co2 is the amount of co2 in the

243
00:08:32,550 --> 00:08:29,759
atmosphere

244
00:08:33,750 --> 00:08:32,560
f org is always kept at 0.2 throughout

245
00:08:36,149 --> 00:08:33,760
the model

246
00:08:38,070 --> 00:08:36,159
and atmospheric oxygen is proportional

247
00:08:39,750 --> 00:08:38,080
to the amount of organic carbon in all

248
00:08:42,149 --> 00:08:39,760
reservoirs

249
00:08:43,829 --> 00:08:42,159
co2 released at mid-ocean ridges is

250
00:08:46,870 --> 00:08:43,839
always minus five per ml

251
00:08:48,949 --> 00:08:46,880
and co2 release at rx

252
00:08:51,269 --> 00:08:48,959
is heavily influenced by the delta 13c

253
00:08:53,509 --> 00:08:51,279
of subducted carbonates

254
00:08:55,030 --> 00:08:53,519
while the delta 13cm co2 released at

255
00:08:56,710 --> 00:08:55,040
oceanine volcanoes

256
00:08:58,710 --> 00:08:56,720
is heavily influenced by subductor

257
00:09:01,190 --> 00:08:58,720
organic carbon

258
00:09:02,870 --> 00:09:01,200
next carbonates are recycled on the

259
00:09:04,710 --> 00:09:02,880
order of tens of millions of years

260
00:09:07,990 --> 00:09:04,720
while organic carbon is released on the

261
00:09:09,269 --> 00:09:08,000
order of hundreds of millions of years

262
00:09:11,110 --> 00:09:09,279
so now i'm going to walk you through the

263
00:09:11,430 --> 00:09:11,120

model results with some red shadings to

264
00:09:13,030 --> 00:09:11,440
help

265
00:09:14,870 --> 00:09:13,040
emphasize where the processes are

266
00:09:16,790 --> 00:09:14,880
occurring on the schematic and how it

267
00:09:18,949 --> 00:09:16,800
translates to the model

268
00:09:20,870 --> 00:09:18,959
so the top panel shows the delta 13c of

269
00:09:21,509 --> 00:09:20,880
marine carbonates with natural data in

270
00:09:24,070 --> 00:09:21,519
blue

271
00:09:26,070 --> 00:09:24,080
and model results in orange the second

272
00:09:26,710 --> 00:09:26,080
panel shows atmospheric oxygen levels

273
00:09:29,670 --> 00:09:26,720
through time

274
00:09:31,190 --> 00:09:29,680
with estimates with estimates based on

275
00:09:34,389 --> 00:09:31,200
proxy measurements in blue

276
00:09:36,070 --> 00:09:34,399
and model results in orange the third

277
00:09:37,350 --> 00:09:36,080
panel shows carbon fluxes from

278
00:09:39,590 --> 00:09:37,360
weathering or

279
00:09:42,230 --> 00:09:39,600
or carbon burial and different volcanic

280
00:09:44,150 --> 00:09:42,240
settings while the final panel shows k

281
00:09:45,590 --> 00:09:44,160
which is a variable variable that

282
00:09:47,509 --> 00:09:45,600
controls how sensitive

283
00:09:48,949 --> 00:09:47,519
continental weathering is to atmospheric

284
00:09:50,710 --> 00:09:48,959
co2

285
00:09:52,470 --> 00:09:50,720
now k is the only variable we are

286
00:09:53,670 --> 00:09:52,480
prescribing changes to in the model to

287
00:09:58,470 --> 00:09:53,680
generate the model

288
00:10:01,030 --> 00:09:58,480

run shown so at 2.4 billion years

289
00:10:02,230 --> 00:10:01,040
ago we increased k which increases the

290
00:10:04,710 --> 00:10:02,240
weathering flux

291
00:10:06,310 --> 00:10:04,720
resulting in increased carbon burial and

292
00:10:08,790 --> 00:10:06,320
subduction

293
00:10:09,910 --> 00:10:08,800
this increased carbon barrel results in

294
00:10:12,550 --> 00:10:09,920
an increase in

295
00:10:14,710 --> 00:10:12,560
oxygen and shortly after there is

296
00:10:17,350 --> 00:10:14,720
increase

297
00:10:19,430 --> 00:10:17,360
in the arc co2 flux due to the release

298
00:10:22,069 --> 00:10:19,440
of subducted carbonates

299
00:10:22,710 --> 00:10:22,079
after the initial increase in k we

300
00:10:27,030 --> 00:10:22,720
prescribe

301
00:10:29,670 --> 00:10:27,040
k to decay to a lower value therefore

302
00:10:32,230 --> 00:10:29,680
the weathering flux also decays now the

303
00:10:35,750 --> 00:10:32,240
arc flux rapidly responds to the surface

304
00:10:37,750 --> 00:10:35,760
changes so the arc flux decays as well

305
00:10:39,430 --> 00:10:37,760
after about 300 million years the

306
00:10:41,750 --> 00:10:39,440
increased flux of organic carbon is

307
00:10:43,590 --> 00:10:41,760
released at ocean island volcanoes

308
00:10:45,350 --> 00:10:43,600
and since the arc flux has already

309
00:10:47,910 --> 00:10:45,360
decayed the ocean island flux

310
00:10:48,710 --> 00:10:47,920
dominates global co2 emissions and this

311
00:10:51,829 --> 00:10:48,720
results

312
00:10:53,829 --> 00:10:51,839
in a negative carbon isotope extrusion

313
00:10:55,030 --> 00:10:53,839

directly following the positive carbon

314
00:10:57,670 --> 00:10:55,040
isotope excursion

315
00:10:58,790 --> 00:10:57,680
which has been observed in the natural

316
00:11:01,910 --> 00:10:58,800
data

317
00:11:03,670 --> 00:11:01,920
now we repeat this k increase at 1.4 and

318
00:11:06,069 --> 00:11:03,680
0.8 billion years ago

319
00:11:06,790 --> 00:11:06,079
and the model does a good job of

320
00:11:09,350 --> 00:11:06,800
reproducing

321
00:11:15,350 --> 00:11:09,360
both the delta 13c and oxygen curve for

322
00:11:17,110 --> 00:11:15,360
nearly the entirety of earth history

323
00:11:19,190 --> 00:11:17,120
so i'd like to wrap up by talking a

324
00:11:21,350 --> 00:11:19,200
little bit about how this process is

325
00:11:24,550 --> 00:11:21,360
related to tectonic cycling

326
00:11:26,949 --> 00:11:24,560
on the right i had a panel at the bottom

327
00:11:29,509 --> 00:11:26,959
that shows how zircon count

328
00:11:30,310 --> 00:11:29,519
that shows zircon count through time and

329
00:11:31,750 --> 00:11:30,320
zircon

330
00:11:34,310 --> 00:11:31,760
is a mineral that is predominantly

331
00:11:36,870 --> 00:11:34,320
produced at convergent margins

332
00:11:38,389 --> 00:11:36,880
therefore times of high zircon

333
00:11:40,310 --> 00:11:38,399
production are thought to signal

334
00:11:42,310 --> 00:11:40,320
supercontinent formation

335
00:11:45,269 --> 00:11:42,320
while times of low zircon production are

336
00:11:47,590 --> 00:11:45,279
thought to signal supercontinent breakup

337
00:11:49,190 --> 00:11:47,600
i put vertical br gray bands which

338
00:11:49,910 --> 00:11:49,200

encompass all periods of enhanced

339
00:11:51,910 --> 00:11:49,920
weathering

340
00:11:53,110 --> 00:11:51,920
in the model and we can see that all

341
00:11:55,590 --> 00:11:53,120
high weathering periods

342
00:11:56,310 --> 00:11:55,600
initiate during troughs in the zircon

343
00:11:58,550 --> 00:11:56,320
record

344
00:11:59,430 --> 00:11:58,560
which suggests that supercontinent

345
00:12:01,350 --> 00:11:59,440
breakups

346
00:12:02,949 --> 00:12:01,360
may be driving time periods of enhanced

347
00:12:04,550 --> 00:12:02,959
continental weathering

348
00:12:06,629 --> 00:12:04,560
and there are several reasons that

349
00:12:07,750 --> 00:12:06,639
supercontinent breakup may be tied to

350
00:12:10,310 --> 00:12:07,760
enhanced weathering

351
00:12:11,990 --> 00:12:10,320
for one continental breakups are

352
00:12:13,269 --> 00:12:12,000
accompanied by the eruption of large

353
00:12:15,509 --> 00:12:13,279
volumes of basalts

354
00:12:17,590 --> 00:12:15,519
which are highly weatherable and emit

355
00:12:19,430 --> 00:12:17,600
large amounts of co2 which can also

356
00:12:22,230 --> 00:12:19,440
enhance weathering

357
00:12:24,069 --> 00:12:22,240
second continental breakup increases the

358
00:12:26,710 --> 00:12:24,079
area of continental margins

359
00:12:28,310 --> 00:12:26,720
which are the primary locations for the

360
00:12:29,829 --> 00:12:28,320
deposition of organic carbon and

361
00:12:31,910 --> 00:12:29,839
carbonates

362
00:12:34,150 --> 00:12:31,920
so in conclusion we propose that

363
00:12:34,949 --> 00:12:34,160

supercontinent breakups drive enhanced

364
00:12:37,750 --> 00:12:34,959
weathering

365
00:12:37,990 --> 00:12:37,760
which leads to enhanced carbon burial

366
00:12:39,910 --> 00:12:38,000
and

367
00:12:42,470 --> 00:12:39,920
when this is coupled with a deep carbon

368
00:12:44,790 --> 00:12:42,480
cycling can explain oxygenation

369
00:12:45,829 --> 00:12:44,800
oxygenation events and carbon isotope