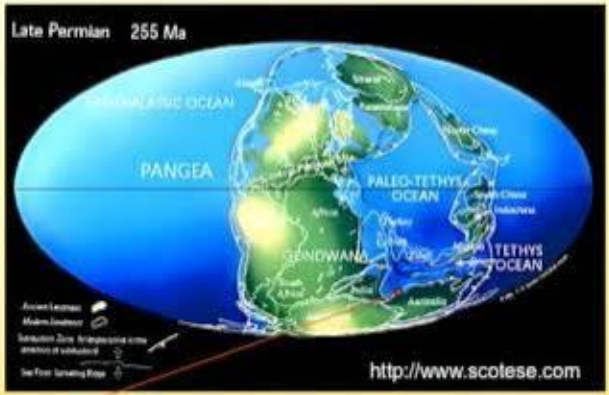
NASA Astrobiology Institute

Director's Seminar Series

# Perth Basin: Grice et al., 2005




Early Triassic Kockatea Shales of the Perth Basin on southern limit of Paleotethys ocean at high southerly latitudes

***Science 307*, 706-9, 2005**

1
00:00:06,710 --> 00:00:03,860
well welcome everyone to the latest the

2
00:00:09,320 --> 00:00:06,720
last for this calendar year in the

3
00:00:11,240 --> 00:00:09,330
series of Nai director seminars and we

4
00:00:13,360 --> 00:00:11,250
are very fortunate to have Professor

5
00:00:15,799 --> 00:00:13,370
Roger summons from MIT

6
00:00:18,560 --> 00:00:15,809
speaking to us today and just to

7
00:00:22,640 --> 00:00:18,570
demonstrate the inter team collaboration

8
00:00:25,790 --> 00:00:22,650
he is speaking from JPL where of course

9
00:00:27,710 --> 00:00:25,800
we have two new teams that have just

10
00:00:31,370 --> 00:00:27,720
come on board or just coming on board

11
00:00:34,100 --> 00:00:31,380
the Institute Roger is the head of the

12
00:00:37,310 --> 00:00:34,110
Geo biology group at MIT

13
00:00:39,200 --> 00:00:37,320

he's a very distinguished scientist who

14
00:00:41,060 --> 00:00:39,210
I think probably needs almost no

15
00:00:42,650 --> 00:00:41,070
introduction to this group I will

16
00:00:44,619 --> 00:00:42,660
mention that he's a fellow of the Royal

17
00:00:48,170 --> 00:00:44,629
Society

18
00:00:51,020 --> 00:00:48,180
comes to us from the Australian National

19
00:00:54,049 --> 00:00:51,030
University and the University in New

20
00:00:56,299 --> 00:00:54,059
South Wales and he is going to be

21
00:00:57,889 --> 00:00:56,309
speaking to us this morning about what

22
00:00:59,439 --> 00:00:57,899
has been called the mother of all

23
00:01:02,630 --> 00:00:59,449
extinctions the permian-triassic

24
00:01:04,880 --> 00:01:02,640
extinction about 250 million years ago

25
00:01:07,010 --> 00:01:04,890
and his title is the great mass

26
00:01:09,140 --> 00:01:07,020
extinction a sudden event or a

27
00:01:11,210 --> 00:01:09,150
slow-moving train wreck and Roger

28
00:01:13,120 --> 00:01:11,220
without further ado I'll turn it over to

29
00:01:15,340 --> 00:01:13,130
you thank

30
00:01:17,840 --> 00:01:15,350
you very much call

31
00:01:20,230 --> 00:01:17,850
perhaps I should explain this title a

32
00:01:22,760 --> 00:01:20,240
little bit better

33
00:01:25,999 --> 00:01:22,770
I'm sure many of you are aware this is

34
00:01:29,179 --> 00:01:26,009
the largest mass extinction that's

35
00:01:30,710 --> 00:01:29,189
recorded in the geological record and a

36
00:01:33,890 --> 00:01:30,720
lot of the hypotheses about this

37
00:01:36,770 --> 00:01:33,900
extinction point suggest that is a

38
00:01:39,830 --> 00:01:36,780

really sudden event I was explaining it

39
00:01:42,109 --> 00:01:39,840
my data to a colleague John Hayes and he

40
00:01:43,789 --> 00:01:42,119
said I think a better description is

41
00:01:45,910 --> 00:01:43,799
slow-moving train wreck so that's the

42
00:01:47,719 --> 00:01:45,920
origin of the title

43
00:01:50,990 --> 00:01:47,729
your work I'm going to speak about

44
00:01:53,569 --> 00:01:51,000
involves many people in particular group

45
00:01:58,120 --> 00:01:53,579
from the Nanjing Institute of geology

46
00:02:02,660 --> 00:02:00,350
myself Gordon Love and Lindsey Hayes

47
00:02:03,889 --> 00:02:02,670
working from MIT and a number of

48
00:02:07,399 --> 00:02:03,899
colleagues from around the world who

49
00:02:11,640 --> 00:02:07,409
provided geological sections for this

50
00:02:16,410 --> 00:02:13,350
should also say that the worker was

51
00:02:18,780 --> 00:02:16,420
funded almost entirely by the NASA

52
00:02:22,229 --> 00:02:18,790
exobiology program and I'm very grateful

53
00:02:24,110 --> 00:02:22,239
for the support of the X apology program

54
00:02:29,180 --> 00:02:24,120
over many years

55
00:02:34,039 --> 00:02:33,240
Marcus and proxies for biogeochemical

56
00:02:36,900 --> 00:02:34,049
processes

57
00:02:40,589 --> 00:02:36,910
in particular I talked about biomarkers

58
00:02:43,530 --> 00:02:40,599
for the green sulfur bacteria a coupling

59
00:02:45,240 --> 00:02:43,540
of the carbon and sulfur cycles and then

60
00:02:47,309 --> 00:02:45,250
I'll talk about this event as it's

61
00:02:49,740 --> 00:02:47,319
recorded different places around the

62
00:02:51,990 --> 00:02:49,750
world and particularly the event as

63
00:02:53,509 --> 00:02:52,000

recorded with the type section in South

64
00:02:56,280 --> 00:02:53,519
China

65
00:02:59,580 --> 00:02:56,290
we've published one paper on this on

66
00:03:01,309 --> 00:02:59,590
this particular event the first author's

67
00:03:05,360 --> 00:03:01,319
plead rice from

68
00:03:07,229 --> 00:03:05,370
that appeared in science in 2005

69
00:03:08,960 --> 00:03:07,239
basically there's an update of that

70
00:03:12,630 --> 00:03:08,970
paper

71
00:03:13,190 --> 00:03:12,640
first of all the biomarker principle the

72
00:03:15,710 --> 00:03:13,200
idea

73
00:03:18,629 --> 00:03:15,720
invited here is that

74
00:03:20,970 --> 00:03:18,639
we can use lipids as proxies for

75
00:03:24,629 --> 00:03:20,980
organisms because many many organisms

76
00:03:26,430 --> 00:03:24,639
make diagnostic lipids the importance of

77
00:03:28,830 --> 00:03:26,440
focusing on lipids is that they are

78
00:03:32,009 --> 00:03:28,840
geologically stable whereas amino acids

79
00:03:34,559 --> 00:03:32,019
and DNA are easily destroyed very soon

80
00:03:37,199 --> 00:03:34,569
after an organism dies lipids quite

81
00:03:39,120 --> 00:03:37,209
recalcitrant they undergo process known

82
00:03:41,580 --> 00:03:39,130
as diagenesis where they lose certain

83
00:03:43,710 --> 00:03:41,590
functional groups but the core lipid or

84
00:03:45,599 --> 00:03:43,720
the core skeleton of the lipid for

85
00:03:49,080 --> 00:03:45,609
example here's Dino stirol' a lipid

86
00:03:50,759 --> 00:03:49,090
that's found in in dinoflagellates the

87
00:03:52,770 --> 00:03:50,769
hydrocarbon skeleton preserved in the

88
00:03:56,059 --> 00:03:52,780

geological record is a hydrocarbon

89
00:04:02,369 --> 00:03:59,099
the other aspect about this is this is

90
00:04:04,979 --> 00:04:02,379
that we can find Dino stirol' in modern

91
00:04:07,170 --> 00:04:04,989
dinoflagellates we can find a marked

92
00:04:09,599 --> 00:04:07,180
increase in the concentration of die

93
00:04:11,879 --> 00:04:09,609
nostril in sediments in the middle

94
00:04:14,759 --> 00:04:11,889
triassic when is the major radiation of

95
00:04:17,219 --> 00:04:14,769
dinoflagellates but we can find Dino

96
00:04:20,280 --> 00:04:17,229
stirol' Ordonez the rain in sediments

97
00:04:24,660 --> 00:04:20,290
that in fact quite old and

98
00:04:27,180 --> 00:04:24,670
perhaps we can make a leap of I guess

99
00:04:29,190 --> 00:04:27,190
faith or judgment here and suggest that

100
00:04:30,840 --> 00:04:29,200
that this hydrocarbon might be coming

101
00:04:32,850 --> 00:04:30,850
from the ancestors of modern

102
00:04:34,710 --> 00:04:32,860
dinoflagellates and particularly some of

103
00:04:36,990 --> 00:04:34,720
the strange mermen attacker attacks that

104
00:04:38,000 --> 00:04:37,000
we find in the neoproterozoic rock

105
00:04:39,800 --> 00:04:38,010
record

106
00:04:43,070 --> 00:04:39,810
the other

107
00:04:47,270 --> 00:04:43,080
idea embodied in this picture is that a

108
00:04:50,880 --> 00:04:47,280
sterile when it's made by a microbe or

109
00:04:53,240 --> 00:04:50,890
alga has a very defined stereochemistry

110
00:04:56,970 --> 00:04:53,250
that is the the

111
00:04:59,400 --> 00:04:56,980
you make a plane through the steroid

112
00:05:02,850 --> 00:04:59,410
ring system the methyl groups and the

113
00:05:03,960 --> 00:05:02,860

alcohol substituent up or down with

114
00:05:06,900 --> 00:05:03,970
respect to the plane of the molecule

115
00:05:09,690 --> 00:05:06,910
itself and there's a single

116
00:05:12,000 --> 00:05:09,700
stereochemistry in a bio lipid when that

117
00:05:14,220 --> 00:05:12,010
molecule becomes buried and undergoes

118
00:05:16,230 --> 00:05:14,230
thermal alteration there are numerous

119
00:05:19,410 --> 00:05:16,240
proposed positions in the molecule that

120
00:05:21,300 --> 00:05:19,420
undergo rearrangement and they do it in

121
00:05:23,910 --> 00:05:21,310
a very specific way so you can use a

122
00:05:25,320 --> 00:05:23,920
stereochemistry of the product to give

123
00:05:27,240 --> 00:05:25,330
you some information about the thermal

124
00:05:29,970 --> 00:05:27,250
history of the sediment and you can also

125
00:05:32,970 --> 00:05:29,980
use this geological stereochemistry they

126
00:05:34,650 --> 00:05:32,980
distinguish between modern lipids and

127
00:05:36,540 --> 00:05:34,660
ancient counterparts because you can

128
00:05:39,900 --> 00:05:36,550
only get the ancient counterpart through

129
00:05:42,440 --> 00:05:39,910
a long period of time of heating when in

130
00:05:45,360 --> 00:05:42,450
buried in rocks

131
00:05:47,970 --> 00:05:45,370
the analytical methodology we use

132
00:05:50,760 --> 00:05:47,980
basically we're looking for fresh clean

133
00:05:52,730 --> 00:05:50,770
and particularly organic rich rocks we

134
00:05:55,190 --> 00:05:52,740
extract those rocks with solvents

135
00:05:58,170 --> 00:05:55,200
extract out the lipids

136
00:06:00,420 --> 00:05:58,180
we get a bitumen which is a very complex

137
00:06:02,190 --> 00:06:00,430
mixture we clean that up by different

138
00:06:04,320 --> 00:06:02,200

kinds of chromatography particularly

139
00:06:05,630 --> 00:06:04,330
liquid chromatography and we separate

140
00:06:08,130 --> 00:06:05,640
out different

141
00:06:09,560 --> 00:06:08,140
fractions of hydrocarbons based on their

142
00:06:12,360 --> 00:06:09,570
polarity

143
00:06:15,060 --> 00:06:12,370
and then we analyze those products using

144
00:06:16,100 --> 00:06:15,070
a high sensitivity high resolution GCMs

145
00:06:18,570 --> 00:06:16,110
system that gives us both

146
00:06:20,460 --> 00:06:18,580
identifications as well as quantitative

147
00:06:23,300 --> 00:06:20,470
information provided we've got the right

148
00:06:27,340 --> 00:06:23,310
kinds of internal standards

149
00:06:29,080 --> 00:06:27,350
and some examples of lipids that we use

150
00:06:30,540 --> 00:06:29,090
in particular and then I will talk about

151
00:06:32,620 --> 00:06:30,550
bit later on

152
00:06:35,140 --> 00:06:32,630
bacterial hope pains are a very

153
00:06:37,960 --> 00:06:35,150
important class of phospholipids come

154
00:06:40,240 --> 00:06:37,970
from the bacteria hoping polyols of

155
00:06:42,070 --> 00:06:40,250
different kinds of bacteria sometimes

156
00:06:44,320 --> 00:06:42,080
they have distinguishing features such

157
00:06:46,150 --> 00:06:44,330
as this compound here as an extra methyl

158
00:06:49,380 --> 00:06:46,160
group at this position here position

159
00:06:52,120 --> 00:06:49,390
three so these are three methyl hi pants

160
00:06:53,670 --> 00:06:52,130
predominant source is probably bacteria

161
00:06:57,190 --> 00:06:53,680
that eat methane

162
00:06:58,960 --> 00:06:57,200
for a living if we have a methyl group

163
00:07:01,690 --> 00:06:58,970

on the other hand at position two here

164
00:07:04,480 --> 00:07:01,700
this lipid is found in many many kinds

165
00:07:07,450 --> 00:07:04,490
of saina bacteria roughly 65% whether

166
00:07:09,400 --> 00:07:07,460
cyanobacteria or sorry 35 % attack teria

167
00:07:12,250 --> 00:07:09,410
we studied make this particular lipid

168
00:07:15,460 --> 00:07:12,260
and then algae in particular makes

169
00:07:17,470 --> 00:07:15,470
interesting this distinctive compounds

170
00:07:19,360 --> 00:07:17,480
and because there have been major

171
00:07:20,010 --> 00:07:19,370
radiations and changes in the algal

172
00:07:22,690 --> 00:07:20,020
communities

173
00:07:24,850 --> 00:07:22,700
over geological time sometimes these

174
00:07:27,220 --> 00:07:24,860
particular molecules are very useful as

175
00:07:28,960 --> 00:07:27,230
age diagnostic biomarkers because they

176
00:07:30,640 --> 00:07:28,970
appear in the fossil record the

177
00:07:32,290 --> 00:07:30,650
molecules appear in the fossil record at

178
00:07:34,480 --> 00:07:32,300
about the site at the same time as we

179
00:07:37,440 --> 00:07:34,490
see micro fossils representing some

180
00:07:44,020 --> 00:07:41,220
carotenoids are also very

181
00:07:47,080 --> 00:07:44,030
useful compounds particularly in modern

182
00:07:49,740 --> 00:07:47,090
organisms many many photosynthetic

183
00:07:53,020 --> 00:07:49,750
organisms in fact make distinctive

184
00:07:55,120 --> 00:07:53,030
carotenoids things like B the carotene

185
00:07:58,080 --> 00:07:55,130
or lycopene which is shown on this slide

186
00:08:00,580 --> 00:07:58,090
are quite nonspecific

187
00:08:01,960 --> 00:08:00,590
because for example sign of bacteria and

188
00:08:04,770 --> 00:08:01,970

higher plants will both make

189
00:08:07,720 --> 00:08:04,780
beta-carotene

190
00:08:09,670 --> 00:08:07,730
on the other hand carotenoids with have

191
00:08:11,800 --> 00:08:09,680
which have aromatic ring systems are in

192
00:08:15,070 --> 00:08:11,810
fact restricted in their distributions

193
00:08:18,310 --> 00:08:15,080
and I show here two carotenoids that are

194
00:08:20,470 --> 00:08:18,320
found in the phototrophic green sulfur

195
00:08:22,240 --> 00:08:20,480
bacteria a note that they have a

196
00:08:24,730 --> 00:08:22,250
particular arrangement of the methyl

197
00:08:26,460 --> 00:08:24,740
groups around the ring this one is 2 3 &

198
00:08:28,870 --> 00:08:26,470
6 a

199
00:08:31,180 --> 00:08:28,880
second group of aromatic carotenoids

200
00:08:34,060 --> 00:08:31,190
have a different arrangement of methyl

201
00:08:36,459 --> 00:08:34,070
groups 2 3 4 and they found in the

202
00:08:38,750 --> 00:08:36,469
purple sulfur bacteria they're also

203
00:08:42,540 --> 00:08:38,760
found in sponges which appear to have

204
00:08:45,020 --> 00:08:42,550
bacteria as symbols so these two groups

205
00:08:47,430 --> 00:08:45,030
of of carotenoids

206
00:08:52,520 --> 00:08:47,440
largely confined to two very specific

207
00:08:58,680 --> 00:08:56,760
with respect to coupling of the carbon

208
00:09:01,310 --> 00:08:58,690
and sulfur cycles this is just a cartoon

209
00:09:05,790 --> 00:09:03,900
what a notion of processes go on in the

210
00:09:07,850 --> 00:09:05,800
modern ocean the main one that's

211
00:09:10,500 --> 00:09:07,860
important to us of course of being

212
00:09:15,290 --> 00:09:10,510
oxygenic photosynthesis co2 and water

213
00:09:21,690 --> 00:09:17,910

what we observe in the modern ocean is a

214
00:09:24,390 --> 00:09:21,700
roughly 99% of that organic matter is

215
00:09:27,800 --> 00:09:24,400
rapidly recycled through the process of

216
00:09:30,570 --> 00:09:27,810
respiration so other microbes

217
00:09:32,580 --> 00:09:30,580
plankton fish etc eat that organic

218
00:09:35,010 --> 00:09:32,590
matter and respire it and the cycle

219
00:09:36,960 --> 00:09:35,020
turns but a small amount of the organic

220
00:09:38,940 --> 00:09:36,970
matter will actually sink and escape

221
00:09:40,200 --> 00:09:38,950
into the sediments and a small amount of

222
00:09:42,600 --> 00:09:40,210
the oxygen that's produced in

223
00:09:43,730 --> 00:09:42,610
photosynthesis will escape to the

224
00:09:46,380 --> 00:09:43,740
atmosphere

225
00:09:48,840 --> 00:09:46,390
in once in the sediments organic matter

226
00:09:50,520 --> 00:09:48,850
is respired by the process of sulfate

227
00:09:53,960 --> 00:09:50,530
reduction which is signed by this

228
00:09:57,600 --> 00:09:53,970
equation and basically

229
00:09:59,790 --> 00:09:57,610
probably 99.9% of organic matter

230
00:10:01,290 --> 00:09:59,800
disappears in these two kinds of

231
00:10:04,020 --> 00:10:01,300
respiration that small amount is

232
00:10:05,460 --> 00:10:04,030
preserved in sediments if you actually

233
00:10:08,580 --> 00:10:05,470
increase the amount of organic matter

234
00:10:10,470 --> 00:10:08,590
that's sinking then software production

235
00:10:12,540 --> 00:10:10,480
can actually move out of the sediments

236
00:10:14,730 --> 00:10:12,550
as oxygen is depleted in the deeper

237
00:10:17,300 --> 00:10:14,740
waters the zone of sulfate reduction can

238
00:10:20,490 --> 00:10:17,310

move up into the water column

239
00:10:22,470 --> 00:10:20,500
in fact a classic example of water

240
00:10:25,080 --> 00:10:22,480
column like this would do the carry Arco

241
00:10:27,770 --> 00:10:25,090
basin other places would be basins off

242
00:10:30,770 --> 00:10:27,780
the California borderland

243
00:10:33,840 --> 00:10:30,780
Ventura basic example

244
00:10:35,010 --> 00:10:33,850
now if you have a large amount of really

245
00:10:37,380 --> 00:10:35,020
large amount of organic matter in

246
00:10:39,780 --> 00:10:37,390
terment sediments you can in fact bring

247
00:10:42,260 --> 00:10:39,790
the zone of sulfate reduction up into

248
00:10:44,720 --> 00:10:42,270
the photic zone and

249
00:10:47,810 --> 00:10:44,730
that's on here we call this a use Enoch

250
00:10:49,100 --> 00:10:47,820
water column and the classic example in

251
00:10:52,600 --> 00:10:49,110
modern world would of course be

252
00:10:55,220 --> 00:10:52,610
modern-day Black Sea and is it the

253
00:10:58,460 --> 00:10:55,230
zuni water column is in fact stabilized

254
00:11:00,230 --> 00:10:58,470
because the lower layer is saline water

255
00:11:03,830 --> 00:11:00,240
coming up that's coming through the

256
00:11:05,180 --> 00:11:03,840
Bosphorus and the surface layer is lies

257
00:11:07,940 --> 00:11:05,190
in fresh water that's coming from the

258
00:11:10,480 --> 00:11:07,950
Danube so there's a very stable using it

259
00:11:14,660 --> 00:11:10,490
water column in this case

260
00:11:17,090 --> 00:11:14,670
now the green sulfur bacteria have very

261
00:11:19,520 --> 00:11:17,100
distinctive physiology basically they

262
00:11:22,490 --> 00:11:19,530
carry out an oxygen in photosynthesis

263
00:11:25,730 --> 00:11:22,500

shown here that absolute requirement for

264
00:11:27,620 --> 00:11:25,740
light and hydrogen sulfide which is the

265
00:11:30,310 --> 00:11:27,630
electron donor for photosynthesis so the

266
00:11:34,370 --> 00:11:30,320
hydrogen sulfide replaces the water that

267
00:11:37,640 --> 00:11:34,380
aerobic organisms are using oxygen a

268
00:11:40,120 --> 00:11:37,650
photo synthesis that is using there are

269
00:11:41,930 --> 00:11:40,130
two kinds of green sulfur bacteria

270
00:11:44,420 --> 00:11:41,940
there's what's called the brown

271
00:11:46,670 --> 00:11:44,430
pigmented form which can use low light

272
00:11:49,010 --> 00:11:46,680
or relatively low light and a green

273
00:11:50,810 --> 00:11:49,020
pigment mentat form which requires

274
00:11:53,300 --> 00:11:50,820
higher light intensities and the light

275
00:11:55,780 --> 00:11:53,310
harvesting of these two systems is

276
00:11:57,580 --> 00:11:55,790
controlled by their pigment compositions

277
00:12:00,110 --> 00:11:57,590
and

278
00:12:03,440 --> 00:12:00,120
the green sulfur bacteria so said before

279
00:12:05,780 --> 00:12:03,450
produce these carotenoids either any

280
00:12:08,300 --> 00:12:05,790
Rutina and chloride bactine and these

281
00:12:10,390 --> 00:12:08,310
compounds in fact have high to carbon

282
00:12:13,820 --> 00:12:10,400
stable hydrocarbon

283
00:12:16,490 --> 00:12:13,830
products eyes are any retain and chloro

284
00:12:18,560 --> 00:12:16,500
bactine and in fact the preservation of

285
00:12:20,840 --> 00:12:18,570
these pigments is enhanced by the

286
00:12:23,360 --> 00:12:20,850
environment in which the pigments are

287
00:12:26,300 --> 00:12:23,370
formed in a soft feeding water column

288
00:12:27,830 --> 00:12:26,310

this highly unsaturated center of the

289
00:12:30,380 --> 00:12:27,840
carotenoid ring system becomes

290
00:12:32,180 --> 00:12:30,390
authorized it reacts with the hydrogen

291
00:12:34,790 --> 00:12:32,190
sulfide that's also in the water column

292
00:12:37,700 --> 00:12:34,800
it reduces the double bonds and it

293
00:12:40,760 --> 00:12:37,710
produces a very highly stable carotenoid

294
00:12:42,560 --> 00:12:40,770
pigment it's not a pigment anymore it's

295
00:12:44,540 --> 00:12:42,570
it's it's preserving the aromatic ring

296
00:12:46,880 --> 00:12:44,550
system that the chain along the middle

297
00:12:48,980 --> 00:12:46,890
is in fact saturated and then we can

298
00:12:50,990 --> 00:12:48,990
identify this particular compound and

299
00:12:53,420 --> 00:12:51,000
its other diagenetic products the

300
00:12:55,889 --> 00:12:53,430
fragments of this molecule by focusing

301
00:12:57,629 --> 00:12:55,899
on just two ions in that spectrum the

302
00:12:59,900 --> 00:12:57,639
diagnostic ions that come from this

303
00:13:04,439 --> 00:12:59,910
particular fragment here is with mass

304
00:13:06,319 --> 00:13:04,449
133 134 so it's a very nice system to

305
00:13:08,639 --> 00:13:06,329
illustrate use of biomarkers because

306
00:13:10,199 --> 00:13:08,649
actually everything goes together the

307
00:13:11,790 --> 00:13:10,209
formation and the molecules as well as

308
00:13:15,050 --> 00:13:11,800
the preservation system that allows us

309
00:13:18,290 --> 00:13:15,060
to find the fossils in rocks as old as

310
00:13:21,619 --> 00:13:18,300
1.7 billion years

311
00:13:24,559 --> 00:13:21,629
now turn to the mass extinction itself

312
00:13:27,150 --> 00:13:24,569
these are fairly old

313
00:13:30,869 --> 00:13:27,160

depictions of the mass extinction they

314
00:13:36,079 --> 00:13:30,879
were published by Jack sepkoski and two

315
00:13:39,290 --> 00:13:36,089
papers in I guess 90 1996

316
00:13:43,790 --> 00:13:39,300
in the diagram shows geological

317
00:13:47,069 --> 00:13:43,800
time starting from the Precambrian here

318
00:13:51,800 --> 00:13:47,079
and the number of families of marine

319
00:13:55,110 --> 00:13:51,810
invertebrates and we can see the

320
00:13:57,389 --> 00:13:55,120
major radiation of invertebrates during

321
00:14:00,030 --> 00:13:57,399
the Cambrian we can see the major

322
00:14:01,470 --> 00:14:00,040
radiation in an order vision in the

323
00:14:03,720 --> 00:14:01,480
Ordovician we can see a drop in

324
00:14:05,730 --> 00:14:03,730
diversity here we can see another drop

325
00:14:07,889 --> 00:14:05,740
in diversity here in the Devonian where

326
00:14:09,449 --> 00:14:07,899
there's a significant mass extinction we

327
00:14:11,699 --> 00:14:09,459
go along here is the Permian Triassic

328
00:14:14,369 --> 00:14:11,709
mass extinction which as you see can

329
00:14:16,519 --> 00:14:14,379
looks like a very sudden event and it's

330
00:14:19,019 --> 00:14:16,529
the largest loss of biodiversity

331
00:14:20,519 --> 00:14:19,029
there's a slow recovery there's another

332
00:14:23,639 --> 00:14:20,529
mass extinction at the end of the

333
00:14:26,309 --> 00:14:23,649
Triassic again increasing diversity up

334
00:14:28,049 --> 00:14:26,319
through the Mesozoic until the end of

335
00:14:36,809 --> 00:14:28,059
the Cretaceous and of course we have the

336
00:14:42,239 --> 00:14:39,379
as I said early on the

337
00:14:44,039 --> 00:14:42,249
great variety of hypotheses about what

338
00:14:46,829 --> 00:14:44,049

caused this event fall into two they

339
00:14:49,829 --> 00:14:46,839
fall into two classes the catastrophic

340
00:14:51,299 --> 00:14:49,839
type such as ideas that came in the

341
00:14:53,759 --> 00:14:51,309
nineteen seventies that was caused by

342
00:14:55,729 --> 00:14:53,769
the earth coming in contact with

343
00:14:58,590 --> 00:14:55,739
radiation from a supernova

344
00:15:01,079 --> 00:14:58,600
as recently as two thousand one Louann

345
00:15:04,619 --> 00:15:01,089
Baker's hypothesized that the agent of

346
00:15:05,639 --> 00:15:04,629
extinction bolide impact is similar to

347
00:15:07,559 --> 00:15:05,649
what happened at the end of the

348
00:15:10,499 --> 00:15:07,569
Cretaceous the other kind of

349
00:15:13,889 --> 00:15:10,509
catastrophic cause these major volcanism

350
00:15:16,289 --> 00:15:13,899
the Siberian traps eruptive massively at

351
00:15:17,509 --> 00:15:16,299
about this time producing large amounts

352
00:15:21,029 --> 00:15:17,519
of

353
00:15:23,219 --> 00:15:21,039
carbon dioxide and perhaps other toxic

354
00:15:25,079 --> 00:15:23,229
gases into the atmosphere and numerous

355
00:15:29,069 --> 00:15:25,089
people have hypothesized that this is in

356
00:15:30,719 --> 00:15:29,079
fact their cause but there are causes in

357
00:15:34,199 --> 00:15:30,729
addition that people have hypothesized

358
00:15:38,210 --> 00:15:34,209
based on geological record for example

359
00:15:41,819 --> 00:15:38,220
climate change lowering of sea level

360
00:15:45,710 --> 00:15:41,829
many people have recognized signals for

361
00:15:49,379 --> 00:15:45,720
ocean stagnation and marine anoxia

362
00:15:51,749 --> 00:15:49,389
excuse me there's a major negative

363
00:15:54,119 --> 00:15:51,759

carbon isotope excursion that marks the

364
00:15:57,449 --> 00:15:54,129
extinction of people hypothesize this is

365
00:15:59,489 --> 00:15:57,459
caused by catastrophic collapse of

366
00:16:01,949 --> 00:15:59,499
methane hydrates in the ocean floor and

367
00:16:04,009 --> 00:16:01,959
that is been in fact much given a

368
00:16:08,249 --> 00:16:04,019
dramatic climate change

369
00:16:10,409 --> 00:16:08,259
and the other hypothesis is that we have

370
00:16:12,359 --> 00:16:10,419
an overturn zenok ocean in fact the

371
00:16:14,599 --> 00:16:12,369
toxic agents are co2 and hydrogen

372
00:16:17,009 --> 00:16:14,609
sulfide communities

373
00:16:18,809 --> 00:16:17,019
and then it's not even as often said

374
00:16:20,819 --> 00:16:18,819
well it's not just one course it's in

375
00:16:25,519 --> 00:16:20,829
fact a combination of these things the

376
00:16:31,019 --> 00:16:28,049
but what about the boundary itself well

377
00:16:34,590 --> 00:16:31,029
there's a severe mass extinction at the

378
00:16:36,979 --> 00:16:34,600
end of the Permian worldwide it's the

379
00:16:39,899 --> 00:16:36,989
end of the chance Union stage

380
00:16:42,329 --> 00:16:39,909
the boundary itself is not defined by

381
00:16:44,729 --> 00:16:42,339
the extinction but it's be defined by a

382
00:16:46,190 --> 00:16:44,739
fossil that marks the beginning of the

383
00:16:48,199 --> 00:16:46,200
Triassic period at the beginning the

384
00:16:50,990 --> 00:16:48,209
Miss of Mississauga and that's a Kona

385
00:16:52,880 --> 00:16:51,000
Don called Hindi ODIs parvis and the

386
00:16:55,009 --> 00:16:52,890
type section that that's used worldwide

387
00:16:58,370 --> 00:16:55,019
for people to correlate to this event is

388
00:17:00,019 --> 00:16:58,380

in motion and China there's also an

389
00:17:02,060 --> 00:17:00,029
extinction on land there's a well known

390
00:17:04,340 --> 00:17:02,070
coal gap there's a lot of coal produced

391
00:17:06,049 --> 00:17:04,350
through the Carboniferous and the and

392
00:17:07,549 --> 00:17:06,059
the Permian and all of a sudden you

393
00:17:10,819 --> 00:17:07,559
reach bits whether you have red beets

394
00:17:13,819 --> 00:17:10,829
and absolutely no coal in Australia it's

395
00:17:16,220 --> 00:17:13,829
defined as the end of the call as well

396
00:17:20,230 --> 00:17:16,230
as a particular kind of plant core

397
00:17:24,409 --> 00:17:22,640
now one of the problems or one of the

398
00:17:26,090 --> 00:17:24,419
issues that's created a lot of

399
00:17:28,760 --> 00:17:26,100
difficulty in understanding this

400
00:17:30,560 --> 00:17:28,770
extension is there's no common agreed

401
00:17:32,419 --> 00:17:30,570
commonly agreed way to correlate the

402
00:17:34,460 --> 00:17:32,429
marine and the terrestrial extinction

403
00:17:37,810 --> 00:17:34,470
there are very poor dates for the tress

404
00:17:40,850 --> 00:17:37,820
the loss of terrestrial organisms and

405
00:17:42,500 --> 00:17:40,860
there's no fossil that occurs both in

406
00:17:44,030 --> 00:17:42,510
marine and terrestrial environments so

407
00:17:46,340 --> 00:17:44,040
this caused a lot of argument in fact

408
00:17:48,530 --> 00:17:46,350
about where the boundary exists on land

409
00:17:51,320 --> 00:17:48,540
and it's a very important problem that

410
00:17:54,350 --> 00:17:51,330
really needs to be addressed there's

411
00:17:55,549 --> 00:17:54,360
also funnel extinction in the

412
00:17:59,680 --> 00:17:55,559
terrestrial environment that's been

413
00:18:02,750 --> 00:17:59,690

described in particularly by Peter Ward

414
00:18:04,460 --> 00:18:02,760
so this complicated diagram and it

415
00:18:07,190 --> 00:18:04,470
basically shows the work that's been

416
00:18:08,570 --> 00:18:07,200
conducted by Professor Jin noog and the

417
00:18:12,049 --> 00:18:08,580
late professor Jenny Organa and his

418
00:18:15,159 --> 00:18:12,059
group working in Nanjing and basically

419
00:18:18,710 --> 00:18:15,169
it shows here the demise of major

420
00:18:21,230 --> 00:18:18,720
taxonomic groups and that occurs in

421
00:18:23,930 --> 00:18:21,240
what's called bed 25 and 26 of the

422
00:18:27,020 --> 00:18:23,940
Martian section but the red line in fact

423
00:18:29,330 --> 00:18:27,030
shows what's the formally defined as the

424
00:18:31,039 --> 00:18:29,340
Triassic the beginning of the Triassic

425
00:18:33,110 --> 00:18:31,049
so that's a little bit later than the

426
00:18:36,070 --> 00:18:33,120
actual mass extinction it's off for the

427
00:18:38,230 --> 00:18:36,080
main phase of mass extinction

428
00:18:40,970 --> 00:18:38,240
and the

429
00:18:46,130 --> 00:18:40,980
main extinction horizon I said is it's

430
00:18:48,230 --> 00:18:46,140
25 and 26 and that the age of that

431
00:18:49,880 --> 00:18:48,240
particular event is also marked by an

432
00:18:52,669 --> 00:18:49,890
Aspie that my shown is one of the

433
00:18:54,440 --> 00:18:52,679
reasons my Jean was selected as a type

434
00:18:56,999 --> 00:18:54,450
section because the volcanic ash bed

435
00:19:00,930 --> 00:18:57,009
with Sir ones that that have been dated

436
00:19:03,359 --> 00:19:00,940
very accurately now by my colleague Sam

437
00:19:05,549 --> 00:19:03,369
bearing and and also by others so

438
00:19:07,259 --> 00:19:05,559

there's a now pretty common agreement

439
00:19:09,449 --> 00:19:07,269
that this is this event took place at

440
00:19:12,199 --> 00:19:09,459
two fifty two point two million years

441
00:19:18,719 --> 00:19:14,969
the section of type section itself is an

442
00:19:21,019 --> 00:19:18,729
hour Geopark and in my jean so this is a

443
00:19:24,239 --> 00:19:21,029
monument to the mass extinction here's a

444
00:19:27,060 --> 00:19:24,249
ginormous version of the lakota dot

445
00:19:28,639 --> 00:19:27,070
which is basically the toothed part of

446
00:19:31,589 --> 00:19:28,649
an enigmatic

447
00:19:34,409 --> 00:19:31,599
fish of some kind perhaps there's some

448
00:19:36,749 --> 00:19:34,419
geo tourists and here is Professor Jinyu

449
00:19:40,819 --> 00:19:36,759
again who's basically led the definition

450
00:19:43,889 --> 00:19:40,829
of the event at my show and

451
00:19:46,139 --> 00:19:43,899
the actual pipe section is up on this

452
00:19:49,379 --> 00:19:46,149
rock face here so you can actually walk

453
00:19:51,479 --> 00:19:49,389
along a path here through the last part

454
00:19:52,889 --> 00:19:51,489
of the Permian till you come to the very

455
00:19:55,589 --> 00:19:52,899
end of the Permian there's actually a

456
00:19:56,940 --> 00:19:55,599
golden spike that's stuck into the into

457
00:20:00,060 --> 00:19:56,950
the rock face there and that's the

458
00:20:02,060 --> 00:20:00,070
official boundary now since it's a Geo

459
00:20:03,869 --> 00:20:02,070
Park and it's a defined

460
00:20:05,609 --> 00:20:03,879
geological site of a site of great

461
00:20:07,709 --> 00:20:05,619
geological interest you can't take

462
00:20:09,810 --> 00:20:07,719
samples from here anymore very early on

463
00:20:11,369 --> 00:20:09,820

you can actually collect from here that

464
00:20:13,349 --> 00:20:11,379
now it's impossible to do that so you

465
00:20:15,469 --> 00:20:13,359
have to collect from sections of this

466
00:20:20,299 --> 00:20:15,479
that are several kilometers

467
00:20:24,989 --> 00:20:20,309
several kilometers away and in 1994

468
00:20:27,509 --> 00:20:24,999
sorry 2004 professor gen organized a

469
00:20:30,599 --> 00:20:27,519
drilling project and this is because if

470
00:20:32,999 --> 00:20:30,609
the actual outcrop this is in fact quite

471
00:20:34,529 --> 00:20:33,009
heavily weathered and in order to get

472
00:20:36,119 --> 00:20:34,539
fresh samples to do a really good

473
00:20:38,579 --> 00:20:36,129
geochemical study professor jena

474
00:20:40,769 --> 00:20:38,589
organized a drilling of a thank several

475
00:20:43,349 --> 00:20:40,779
course and our samples that i'll talk

476
00:20:45,509 --> 00:20:43,359
about now come from what's called the

477
00:20:48,180 --> 00:20:45,519
micelle one core and the core was

478
00:20:50,999 --> 00:20:48,190
actually drilled and and samples

479
00:20:54,209 --> 00:20:51,009
collected by my very good colleague Chow

480
00:20:56,249 --> 00:20:54,219
Changchun we looked at a roughly 120

481
00:20:58,709 --> 00:20:56,259
samples from the late permian through

482
00:21:01,119 --> 00:20:58,719
the mid Triassic then we measured Bach

483
00:21:06,239 --> 00:21:01,129
geochemical parameters as well as

484
00:21:11,409 --> 00:21:08,889
so I'm going to show you some plots of

485
00:21:13,950 --> 00:21:11,419
the data we've got so here isn't now

486
00:21:16,239 --> 00:21:13,960
it's probably too small to see but

487
00:21:19,119 --> 00:21:16,249
basically this is the mice on

488
00:21:21,639 --> 00:21:19,129

stratigraphy the extinction horizon is

489
00:21:24,070 --> 00:21:21,649
marked by the yellow zone here and then

490
00:21:27,580 --> 00:21:24,080
we have the beginning of the Triassic at

491
00:21:29,200 --> 00:21:27,590
this point here there's quite distinct

492
00:21:30,999 --> 00:21:29,210
changes in mythology as you've got

493
00:21:32,649 --> 00:21:31,009
through the sedimentary package the

494
00:21:34,659 --> 00:21:32,659
sediments in the late permian are

495
00:21:37,330 --> 00:21:34,669
largely carbonates and they replaced

496
00:21:39,970 --> 00:21:37,340
very suddenly at the boundary by clastic

497
00:21:43,060 --> 00:21:39,980
sediments and this is the relative sea

498
00:21:45,220 --> 00:21:43,070
level curve that's been drawn for my

499
00:21:47,859 --> 00:21:45,230
Shawn in fact write out the extinction

500
00:21:51,210 --> 00:21:47,869
event is to sea level low and that is

501
00:21:55,960 --> 00:21:53,739
so the next plot is showing the

502
00:21:58,539 --> 00:21:55,970
distribution of strontium isotopes

503
00:22:00,669 --> 00:21:58,549
without going into great detail this

504
00:22:03,279 --> 00:22:00,679
increase in the strontium isotope ratio

505
00:22:05,700 --> 00:22:03,289
just here is a signal for weathering in

506
00:22:08,229 --> 00:22:05,710
fact what it what it represents is

507
00:22:10,470 --> 00:22:08,239
strontium from Granite's entering into

508
00:22:12,909 --> 00:22:10,480
the ocean and that's a signal that

509
00:22:15,549 --> 00:22:12,919
basically there's a withering event

510
00:22:18,009 --> 00:22:15,559
associated with this and these ages here

511
00:22:20,320 --> 00:22:18,019
are all from individual aspects that

512
00:22:22,210 --> 00:22:20,330
occur through the late permian showing

513
00:22:24,190 --> 00:22:22,220

that we now have very very good quiet

514
00:22:25,019 --> 00:22:24,200
time control of the events leading up

515
00:22:28,119 --> 00:22:25,029
into

516
00:22:30,249 --> 00:22:28,129
the event itself there's about one and a

517
00:22:33,159 --> 00:22:30,259
half million years embodied in this last

518
00:22:34,389 --> 00:22:33,169
part of the Permian of chanc senior and

519
00:22:36,159 --> 00:22:34,399
there's another million or a

520
00:22:37,960 --> 00:22:36,169
million-and-a-half embodied in the

521
00:22:39,580 --> 00:22:37,970
section up through the first part of the

522
00:22:42,430 --> 00:22:39,590
Triassic so it's roughly three million

523
00:22:43,950 --> 00:22:42,440
years embodied in the sediments we don't

524
00:22:47,440 --> 00:22:43,960
be talking about

525
00:22:50,229 --> 00:22:47,450
as I said the event is marked by a major

526
00:22:51,999 --> 00:22:50,239
carbon isotope dispersion and that is

527
00:22:54,940 --> 00:22:52,009
shown just here in fact correlates very

528
00:22:58,060 --> 00:22:54,950
nicely with this strontium isotope curve

529
00:22:59,529 --> 00:22:58,070
and overlaying on the slower carbon

530
00:23:02,310 --> 00:22:59,539
isotope excursion which is a thing most

531
00:23:04,479 --> 00:23:02,320
people measure is a very very sharp

532
00:23:06,519 --> 00:23:04,489
excursion here so this in fact a double

533
00:23:08,460 --> 00:23:06,529
dispersion these events going on to

534
00:23:11,360 --> 00:23:08,470
timescales

535
00:23:14,310 --> 00:23:11,370
Shawn by this particular curve

536
00:23:18,180 --> 00:23:14,320
so that's a carbonate carbon here's the

537
00:23:20,040 --> 00:23:18,190
organic carbon the there's a again a

538
00:23:22,440 --> 00:23:20,050

very very sharp spike another

539
00:23:24,840 --> 00:23:22,450
interesting aspect of this is that the

540
00:23:26,880 --> 00:23:24,850
sharp spike in organic carbon is not

541
00:23:29,610 --> 00:23:26,890
exactly at the same time as a shark's

542
00:23:31,710 --> 00:23:29,620
sharp spike in carbonate carbon so again

543
00:23:33,840 --> 00:23:31,720
there's an anomaly in the time scale to

544
00:23:36,630 --> 00:23:33,850
the residence times inorganic carbon and

545
00:23:39,000 --> 00:23:36,640
carbonate carbon in the ocean that may

546
00:23:41,760 --> 00:23:39,010
be useful later in in understanding as

547
00:23:43,460 --> 00:23:41,770
the mechanisms of these isotopic changes

548
00:23:49,350 --> 00:23:43,470
and

549
00:23:53,420 --> 00:23:49,360
important thing to observe here is that

550
00:23:56,940 --> 00:23:53,430
we are going from the late permian

551
00:23:59,880 --> 00:23:56,950
with values that are around about plus 2

552
00:24:01,700 --> 00:23:59,890
to plus 3 and that is very typical of

553
00:24:05,610 --> 00:24:01,710
what the values of

554
00:24:07,740 --> 00:24:05,620
nitrate that you find in the ocean so in

555
00:24:09,780 --> 00:24:07,750
the Permian we we have values that are

556
00:24:12,180 --> 00:24:09,790
typical of what you find in the modern

557
00:24:13,980 --> 00:24:12,190
modern ocean but as we get close to the

558
00:24:16,560 --> 00:24:13,990
boundary you can see there's a very

559
00:24:17,820 --> 00:24:16,570
gradual trend towards lower values and

560
00:24:20,340 --> 00:24:17,830
right at the boundaries a sharp spike

561
00:24:22,020 --> 00:24:20,350
and at that point the del 15m of

562
00:24:24,210 --> 00:24:22,030
sedimentary organic matter goes negative

563
00:24:26,160 --> 00:24:24,220

and that tells you that there's been a

564
00:24:29,070 --> 00:24:26,170
major change in the nitrogen cycle and

565
00:24:31,770 --> 00:24:29,080
particularly that we've likely snuffed

566
00:24:33,810 --> 00:24:31,780
out nitrogen cycling through nitrate and

567
00:24:36,090 --> 00:24:33,820
that probably the source of organic

568
00:24:37,650 --> 00:24:36,100
nitrogen at these points when it's zero

569
00:24:41,570 --> 00:24:37,660
to negative is in fact the nitrogen

570
00:24:47,280 --> 00:24:44,700
we've identified the presence of the

571
00:24:50,540 --> 00:24:47,290
distinctive carotenoid either any or

572
00:24:55,650 --> 00:24:52,800
so this is a chromatogram of the

573
00:24:58,290 --> 00:24:55,660
diagnostic iron one three four and it

574
00:25:00,390 --> 00:24:58,300
shows the distribution of what we call

575
00:25:03,900 --> 00:25:00,400
errol isoprenoid so they're fragments of

576
00:25:06,210 --> 00:25:03,910
this larger molecule and up here we have

577
00:25:09,510 --> 00:25:06,220
the tiny little peak you can see which

578
00:25:11,850 --> 00:25:09,520
is in fact the intact c40 compound eyes

579
00:25:14,730 --> 00:25:11,860
are any routine and we know that for

580
00:25:17,400 --> 00:25:14,740
sure because we've run standard so we've

581
00:25:19,320 --> 00:25:17,410
compared the the sample with a little

582
00:25:21,790 --> 00:25:19,330
peak with a mixture of reference

583
00:25:25,360 --> 00:25:21,800
carotenoids and we're absolutely that

584
00:25:27,700 --> 00:25:25,370
identification is correct and of course

585
00:25:29,980 --> 00:25:27,710
this is unambiguous marker but the brown

586
00:25:32,170 --> 00:25:29,990
pigmented version of the green sulfur

587
00:25:35,260 --> 00:25:32,180
bacteria and that shows that hydrogen

588
00:25:37,180 --> 00:25:35,270

sulfide must have come within 80 to 100

589
00:25:39,040 --> 00:25:37,190
meters of the sediment surface because

590
00:25:41,140 --> 00:25:39,050
that's a zone where they green sulfur

591
00:25:43,890 --> 00:25:41,150
bacteria live in the modern-day Black

592
00:25:45,910 --> 00:25:43,900
Sea in other places they basically

593
00:25:47,500 --> 00:25:45,920
operate quite well at load a lot of

594
00:25:50,100 --> 00:25:47,510
light intensities and that's the zone

595
00:25:54,310 --> 00:25:50,110
will generally find them

596
00:25:57,040 --> 00:25:54,320
so now we have some biomarker records at

597
00:25:59,530 --> 00:25:57,050
my show and the first one is the arrow

598
00:26:01,180 --> 00:25:59,540
isoprenoids and what you can see is they

599
00:26:03,520 --> 00:26:01,190
actually first appear in the record

600
00:26:06,190 --> 00:26:03,530
right down here in the new tan formation

601
00:26:07,630 --> 00:26:06,200
then gradually the the relative

602
00:26:10,180 --> 00:26:07,640
abundance of these combats and this is

603
00:26:12,130 --> 00:26:10,190
absolute concentration pipe a million of

604
00:26:14,950 --> 00:26:12,140
total organic carbon and you can see a

605
00:26:17,770 --> 00:26:14,960
major spike in the in the presence of

606
00:26:20,200 --> 00:26:17,780
our isoprenoids here in the middle of

607
00:26:23,200 --> 00:26:20,210
the chung chien we get very some very

608
00:26:25,360 --> 00:26:23,210
very large spikes around the boundary

609
00:26:27,760 --> 00:26:25,370
and and in fact you can still find these

610
00:26:31,240 --> 00:26:27,770
compounds in sediments right up into the

611
00:26:33,910 --> 00:26:31,250
early part of the Triassic the actual

612
00:26:35,530 --> 00:26:33,920
intact carotenoid some what follows is

613
00:26:38,260 --> 00:26:35,540

somewhat closely so here we have the

614
00:26:41,500 --> 00:26:38,270
major peak of either any air obtain

615
00:26:45,070 --> 00:26:41,510
again ppm of TOC and again some sharks

616
00:26:48,100 --> 00:26:45,080
sharp spikes at the boundary so we have

617
00:26:50,140 --> 00:26:48,110
a record of marine use zinnia that

618
00:26:54,630 --> 00:26:50,150
predates the mass extinction by at least

619
00:26:57,040 --> 00:26:54,640
and million and a half years

620
00:26:59,410 --> 00:26:57,050
this is a homeowner hope pain index

621
00:27:02,040 --> 00:26:59,420
without going into the detail of how we

622
00:27:04,420 --> 00:27:02,050
derive it basically it's a marker for

623
00:27:06,490 --> 00:27:04,430
transport of organic matter under using

624
00:27:08,500 --> 00:27:06,500
it conditions and the higher the value

625
00:27:10,210 --> 00:27:08,510
the more use in it the water column and

626
00:27:12,880 --> 00:27:10,220
we can see the highest home I hope pain

627
00:27:15,130 --> 00:27:12,890
index again through the Cheng Cheng en

628
00:27:17,740 --> 00:27:15,140
stage in fact the whole of the change in

629
00:27:20,670 --> 00:27:17,750
hand it looks like it's a using it it

630
00:27:23,410 --> 00:27:20,680
has a using water column here at my show

631
00:27:27,700 --> 00:27:23,420
and this is the pristine f---eighteen

632
00:27:29,890 --> 00:27:27,710
ratio again it's another marker for

633
00:27:32,440 --> 00:27:29,900
and oxy City the law again we have very

634
00:27:34,420 --> 00:27:32,450
low values that's more indicative of

635
00:27:36,610 --> 00:27:34,430
more reducing conditions through the

636
00:27:38,470 --> 00:27:36,620
Permian and in fact once we get into the

637
00:27:41,080 --> 00:27:38,480
trace that we have some very significant

638
00:27:42,520 --> 00:27:41,090

spikes so that there's a lot of changes

639
00:27:44,710 --> 00:27:42,530
in the redox state of the water column

640
00:27:47,070 --> 00:27:44,720
going on in the basal part of the

641
00:27:49,510 --> 00:27:47,080
Triassic

642
00:27:50,640 --> 00:27:49,520
it's some biomarkers for microbial

643
00:27:53,530 --> 00:27:50,650
physiology

644
00:27:55,510 --> 00:27:53,540
the curve shown here is the two methyl

645
00:27:57,970 --> 00:27:55,520
ho pain index and I said before that's a

646
00:28:00,100 --> 00:27:57,980
proxy for the imbalance of sign of

647
00:28:02,650 --> 00:28:00,110
bacteria it goes long at a fairly normal

648
00:28:05,470 --> 00:28:02,660
value I think it's about eight or so

649
00:28:07,030 --> 00:28:05,480
percent of all hope a nodes up to till

650
00:28:09,910 --> 00:28:07,040
we get to the boundary and then we see

651
00:28:13,600 --> 00:28:09,920
some very very large values of the two

652
00:28:15,930 --> 00:28:13,610
methyl ho pain index suggesting that at

653
00:28:20,070 --> 00:28:15,940
and after the boundary we in fact have

654
00:28:24,340 --> 00:28:22,660
this is a three methyl ho pain index in

655
00:28:25,660 --> 00:28:24,350
fact these values are also quite high

656
00:28:28,060 --> 00:28:25,670
compared to other parts of the

657
00:28:30,160 --> 00:28:28,070
phanerozoic geological record suggesting

658
00:28:32,490 --> 00:28:30,170
there is an active methane cycle going

659
00:28:35,460 --> 00:28:32,500
on in the water column like my shine

660
00:28:38,500 --> 00:28:35,470
this one is

661
00:28:39,910 --> 00:28:38,510
proportions of steroids now that the

662
00:28:42,760 --> 00:28:39,920
changes in that in this particular

663
00:28:44,100 --> 00:28:42,770

parameter represent changes in the algal

664
00:28:46,860 --> 00:28:44,110
population

665
00:28:50,020 --> 00:28:46,870
but inc them the most

666
00:28:52,810 --> 00:28:50,030
significant result is shown in this last

667
00:28:54,850 --> 00:28:52,820
curve this is the hope they hope pain to

668
00:28:57,730 --> 00:28:54,860
steering ratio and it's a rough proxy

669
00:28:59,470 --> 00:28:57,740
for the proportion of photo pressure in

670
00:29:02,500 --> 00:28:59,480
the water column that are bacteria

671
00:29:05,290 --> 00:29:02,510
versus algae okay and and you can see

672
00:29:07,090 --> 00:29:05,300
they're two in two major spikes in the

673
00:29:09,490 --> 00:29:07,100
hope lanes asturian index is this one

674
00:29:11,230 --> 00:29:09,500
during this channel simeon and this is

675
00:29:14,260 --> 00:29:11,240
the other one that basically takes up

676
00:29:16,600 --> 00:29:14,270
the first part of the Triassic so what I

677
00:29:18,940 --> 00:29:16,610
interpret from this is that instead of

678
00:29:20,500 --> 00:29:18,950
having an algal ocean as we largely have

679
00:29:22,560 --> 00:29:20,510
today of course we have abundant sign of

680
00:29:24,760 --> 00:29:22,570
bacteria in the deep ocean but but

681
00:29:26,560 --> 00:29:24,770
primary producers in shallow ocean are

682
00:29:29,980 --> 00:29:26,570
largely algae that at this particular

683
00:29:33,440 --> 00:29:29,990
time we have basically a bacterial

684
00:29:36,979 --> 00:29:33,450
community being a major source of

685
00:29:39,379 --> 00:29:36,989
new photosynthetic carbon just after the

686
00:29:41,599 --> 00:29:39,389
extinction of it and in fact the values

687
00:29:43,339 --> 00:29:41,609
of this particular parameter you don't

688
00:29:46,009 --> 00:29:43,349

see in the geological record on to you

689
00:29:48,560 --> 00:29:46,019
go back into the mezzo Proterozoic so

690
00:29:51,229 --> 00:29:48,570
these are in fact unprecedented for any

691
00:29:53,829 --> 00:29:51,239
sediments in the phanerozoic record as

692
00:29:58,729 --> 00:29:57,289
maturity all the sediments are my char

693
00:30:01,099 --> 00:29:58,739
have been roughly buried to the same

694
00:30:04,039 --> 00:30:01,109
depth and we expect they should have a

695
00:30:05,509 --> 00:30:04,049
common maturity and that's shown by this

696
00:30:07,279 --> 00:30:05,519
particular graph here which is

697
00:30:09,259 --> 00:30:07,289
representing one of the hope annoyed

698
00:30:12,069 --> 00:30:09,269
maturity parameters and you can see it's

699
00:30:14,989 --> 00:30:12,079
very fairly constant so that looks good

700
00:30:16,999 --> 00:30:14,999
this is the steroid maturity parameter

701
00:30:18,709 --> 00:30:17,009
and you can see this fluctuates a lot

702
00:30:21,229 --> 00:30:18,719
but it fluctuates mostly at the same

703
00:30:23,089 --> 00:30:21,239
time that we had high hope it's in fact

704
00:30:26,060 --> 00:30:23,099
the fluctuations is not a real signal

705
00:30:28,279 --> 00:30:26,070
this is in fact the signal is being

706
00:30:31,190 --> 00:30:28,289
corrupted by the high amounts of

707
00:30:33,979 --> 00:30:31,200
bacteria opines there we've got a couple

708
00:30:36,349 --> 00:30:33,989
of parameters here for other kinds of

709
00:30:38,479 --> 00:30:36,359
hoping oils and these are varying in

710
00:30:41,419 --> 00:30:38,489
very significant ways and this is quite

711
00:30:43,219 --> 00:30:41,429
enigmatic if one particular maturity

712
00:30:45,469 --> 00:30:43,229
parameter so is a fairly constant value

713
00:30:47,629 --> 00:30:45,479

and these other ones are showing these

714
00:30:49,180 --> 00:30:47,639
major fluctuations it shows us some very

715
00:30:52,339 --> 00:30:49,190
unusual

716
00:30:55,629 --> 00:30:52,349
input of bacteria hopanoids to the

717
00:31:01,219 --> 00:30:58,279
yeah I think I should leave it at that

718
00:31:02,719 --> 00:31:01,229
point because look I guess not a lot of

719
00:31:05,349 --> 00:31:02,729
people interested in these arcane

720
00:31:08,089 --> 00:31:05,359
aspects of the biomarker distributions

721
00:31:09,859 --> 00:31:08,099
but in fact what I would say about this

722
00:31:11,810 --> 00:31:09,869
is a very important signals of the types

723
00:31:13,810 --> 00:31:11,820
of organisms that are present in the

724
00:31:16,969 --> 00:31:13,820
water column at this time

725
00:31:18,799 --> 00:31:16,979
now I spoke before about the nitrogen

726
00:31:20,949 --> 00:31:18,809
isotope composition of organic matter at

727
00:31:24,499 --> 00:31:20,959
these sediments and here is a blow-up

728
00:31:26,810 --> 00:31:24,509
expansion of the del 15 end curve for

729
00:31:30,999 --> 00:31:26,820
just around the boundary so here we have

730
00:31:35,029 --> 00:31:31,009
the the fairly heavy values of the late

731
00:31:36,979 --> 00:31:35,039
permian we go down to zero here and then

732
00:31:40,479 --> 00:31:36,989
we have these big fluctuations are going

733
00:31:44,220 --> 00:31:40,489
to negative territory and

734
00:31:47,940 --> 00:31:44,230
these are the peaks of the two hope pain

735
00:31:50,460 --> 00:31:47,950
index it's possible that the source of

736
00:31:52,619 --> 00:31:50,470
newly fixed lighters is in fact die as

737
00:31:54,419 --> 00:31:52,629
atrophic sign of bacteria but the the

738
00:31:56,269 --> 00:31:54,429

peaks in two methyl ho panes don't

739
00:32:00,539 --> 00:31:56,279
exactly correlate with the most negative

740
00:32:03,570 --> 00:32:00,549
values of del 15 n but what does is the

741
00:32:06,570 --> 00:32:03,580
peaks and arrow isoprenoids so we get

742
00:32:09,470 --> 00:32:06,580
these light values of del 15 and when we

743
00:32:13,279 --> 00:32:09,480
have the most views in water column

744
00:32:23,580 --> 00:32:16,879
the boundary

745
00:32:25,430 --> 00:32:23,590
number of hypothesize causes one of the

746
00:32:29,249 --> 00:32:25,440
most prominently

747
00:32:32,779 --> 00:32:29,259
published causes or hypothesis is that

748
00:32:34,860 --> 00:32:32,789
it was in a bolide impact

749
00:32:37,850 --> 00:32:34,870
two papers in science

750
00:32:41,399 --> 00:32:37,860
first of all referring to the

751
00:32:43,799 --> 00:32:41,409
presence of noble gases with an

752
00:32:47,509 --> 00:32:43,809
extraterrestrial signature encased in

753
00:32:49,680 --> 00:32:47,519
full means the boundary and also the

754
00:32:54,710 --> 00:32:49,690
identification of a possible impact

755
00:33:00,509 --> 00:32:57,810
the case for a mass extinction caused by

756
00:33:03,619 --> 00:33:00,519
a bolide at this at this time I think is

757
00:33:09,680 --> 00:33:06,269
so we've been looking at this particular

758
00:33:12,619 --> 00:33:09,690
evidence in some detail

759
00:33:15,990 --> 00:33:12,629
interestingly just a few weeks ago

760
00:33:19,169 --> 00:33:16,000
there was a paper appeared in gia

761
00:33:21,659 --> 00:33:19,179
chemica identifying the source of strong

762
00:33:23,879 --> 00:33:21,669
fluorine envelope arising from laser

763
00:33:26,820 --> 00:33:23,889

desorption mass spectrometric analysis

764
00:33:30,600 --> 00:33:26,830
of mediary meteorite meteoritic sorry in

765
00:33:33,600 --> 00:33:30,610
soluble organic matter by Hamilton's air

766
00:33:36,869 --> 00:33:33,610
and the technique that was used in these

767
00:33:39,480 --> 00:33:36,879
earlier studies to find the full range

768
00:33:41,249 --> 00:33:39,490
was laser desorption mass spectrometry

769
00:33:42,570 --> 00:33:41,259
the full rings have been reported

770
00:33:44,580 --> 00:33:42,580
several in several places in the

771
00:33:47,580 --> 00:33:44,590
geological record but there's also been

772
00:33:49,460 --> 00:33:47,590
identified in meteorites in the plane of

773
00:33:53,279 --> 00:33:49,470
the dust particles and

774
00:33:55,769 --> 00:33:53,289
haman and zero in fact have shown that

775
00:33:57,989 --> 00:33:55,779
that the presence of foreign could in

776
00:33:59,850 --> 00:33:57,999
fact be an a fact of the mass

777
00:34:01,980 --> 00:33:59,860
spectrometric method which was used to

778
00:34:04,919 --> 00:34:01,990
detect the fluorines in the first place

779
00:34:07,919 --> 00:34:04,929
so we've done a study of my chance said

780
00:34:10,169 --> 00:34:07,929
i'm looking for four ends and we use a

781
00:34:11,180 --> 00:34:10,179
different kind of mass spectrometry we

782
00:34:14,280 --> 00:34:11,190
used

783
00:34:15,950 --> 00:34:14,290
electricity to ionize the the sample and

784
00:34:20,609 --> 00:34:15,960
tothe time of flight mass spectrometry

785
00:34:22,069 --> 00:34:20,619
to analyze the products and we obtained

786
00:34:26,550 --> 00:34:22,079
a

787
00:34:30,270 --> 00:34:26,560
shown here so this little this lion

788
00:34:32,190 --> 00:34:30,280

cluster here represents the molecule c60

789
00:34:35,430 --> 00:34:32,200
there's very distinctly of nice because

790
00:34:38,419 --> 00:34:35,440
it's 60 times 12.000 and there's a very

791
00:34:41,760 --> 00:34:38,429
distinctive combination of isotopes

792
00:34:43,829 --> 00:34:41,770
because 1.1 percent of all the carbon is

793
00:34:46,440 --> 00:34:43,839
molecule is carbon 13 and this

794
00:34:50,129 --> 00:34:46,450
particular isotope cluster follows that

795
00:34:52,649 --> 00:34:50,139
rule exactly and then a foreign is prone

796
00:34:54,839 --> 00:34:52,659
to oxidation so you see for in with one

797
00:34:57,030 --> 00:34:54,849
oxygen and the second oxygen and we're

798
00:35:00,079 --> 00:34:57,040
able to detect fullerene using this

799
00:35:03,480 --> 00:35:00,089
method we can detect as little as 3.5

800
00:35:05,550 --> 00:35:03,490
pictograms so we have a very low

801
00:35:10,380 --> 00:35:05,560
detection limit we also were able to

802
00:35:12,150 --> 00:35:10,390
obtain sample of fluorine so with slight

803
00:35:14,339 --> 00:35:12,160
enrichment i think fifteen percent of

804
00:35:16,319 --> 00:35:14,349
twenty percent of carbon 13 and that's

805
00:35:18,059 --> 00:35:16,329
the spectrum shown here and we actually

806
00:35:20,730 --> 00:35:18,069
added this to our extracts of the

807
00:35:22,950 --> 00:35:20,740
sediment so act as a carrier and an

808
00:35:25,980 --> 00:35:22,960
internal standard and in fact this is a

809
00:35:28,800 --> 00:35:25,990
sample of the c-13 enriched fluorine

810
00:35:31,079 --> 00:35:28,810
from an extract from my shine bed 25

811
00:35:32,940 --> 00:35:31,089
that the extinction in fact what you

812
00:35:35,040 --> 00:35:32,950
find is that you can you can find your

813
00:35:37,500 --> 00:35:35,050

carbon 13 labeled material but you can't

814
00:35:40,650 --> 00:35:37,510
find any natural abundance suit well so

815
00:35:42,900 --> 00:35:40,660
basically I think we've disproved the

816
00:35:45,260 --> 00:35:42,910
occurrence of fluorine at the boundary

817
00:35:47,730 --> 00:35:45,270
at emotion

818
00:35:49,440 --> 00:35:47,740
now in order to understand the event

819
00:35:52,140 --> 00:35:49,450
there's no point just looking at my sign

820
00:35:54,630 --> 00:35:52,150
because the world you can have quite

821
00:35:57,839 --> 00:35:54,640
different environments along different

822
00:35:59,550 --> 00:35:57,849
parts of continental margins so now we

823
00:36:02,040 --> 00:35:59,560
can take advantage of the wonderful

824
00:36:04,950 --> 00:36:02,050
premier geographic maps I'll show you

825
00:36:07,559 --> 00:36:04,960
some from Ron Blakey

826
00:36:10,260 --> 00:36:07,569
Northern Arizona University and we can

827
00:36:12,650 --> 00:36:10,270
rotate the continents back to the way

828
00:36:17,579 --> 00:36:12,660
they were at this particular event

829
00:36:19,559 --> 00:36:17,589
roughly 250 260 million years ago so

830
00:36:23,599 --> 00:36:19,569
that's the arrangement of the continents

831
00:36:26,940 --> 00:36:23,609
at 260 now I'm going to show you roughly

832
00:36:29,309 --> 00:36:26,950
255 and this is now a Scot easy map but

833
00:36:33,990 --> 00:36:29,319
it's very similar and the section at my

834
00:36:35,720 --> 00:36:34,000
shine my shine is just here and so you

835
00:36:38,400 --> 00:36:35,730
can see that it's on the

836
00:36:41,780 --> 00:36:38,410
quite close to the equator and it's on

837
00:36:43,799 --> 00:36:41,790
the margin of this palliate ëthis ocean

838
00:36:46,200 --> 00:36:43,809

previously we've looked at samples from

839
00:36:48,870 --> 00:36:46,210
the Perth Basin as Australia which is

840
00:36:51,059 --> 00:36:48,880
down here so this is in quite high

841
00:36:53,599 --> 00:36:51,069
southerly latitude but it's also in the

842
00:36:56,730 --> 00:36:53,609
paleo toothless ocean and again we found

843
00:36:59,400 --> 00:36:56,740
abundant aryl isoprenoid cesses material

844
00:37:00,750 --> 00:36:59,410
from a science paper a couple of years

845
00:37:04,200 --> 00:37:00,760
ago I want to go into it in great detail

846
00:37:07,170 --> 00:37:04,210
but basically as you get to the as you

847
00:37:09,240 --> 00:37:07,180
get to the PTB you can find marked

848
00:37:11,609 --> 00:37:09,250
increases in the abundance of arrow

849
00:37:14,880 --> 00:37:11,619
isoprenoids they're also major isotopes

850
00:37:17,549 --> 00:37:14,890
isotopic anomalies with respect to

851
00:37:18,930 --> 00:37:17,559
pyrite so there's a sulphur isotope

852
00:37:20,579 --> 00:37:18,940
signal at this event but I really

853
00:37:23,579 --> 00:37:20,589
haven't spoken about but you can observe

854
00:37:26,539 --> 00:37:23,589
that in the sediments in base in Western

855
00:37:31,109 --> 00:37:28,160
another

856
00:37:33,510 --> 00:37:31,119
well documented location of the of the

857
00:37:35,099 --> 00:37:33,520
event is in modern-day Tibet that's

858
00:37:38,160 --> 00:37:35,109
actually in the central part of the

859
00:37:40,079 --> 00:37:38,170
tifus ocean Ravana lized some sediments

860
00:37:42,569 --> 00:37:40,089
who came from Richard twitchett this

861
00:37:44,430 --> 00:37:42,579
one's chromatograms here so the bottom

862
00:37:46,530 --> 00:37:44,440
one is our reference standard barrel

863
00:37:48,960 --> 00:37:46,540

isoprenoids and these are all samples

864
00:37:51,059 --> 00:37:48,970
from the Tibet outcrop and we can

865
00:37:53,010 --> 00:37:51,069
identify the presence of our isoprenoids

866
00:37:56,460 --> 00:37:53,020
with their products of breakdown of ice

867
00:38:00,390 --> 00:37:58,440
there was a great paper several years

868
00:38:04,140 --> 00:38:00,400
ago by Jonathan pane and in our

869
00:38:05,910 --> 00:38:04,150
colleagues that described the demise of

870
00:38:07,829 --> 00:38:05,920
organisms and a carbonate reef system

871
00:38:09,900 --> 00:38:07,839
that this particular there and the by

872
00:38:12,690 --> 00:38:09,910
photography is shown here

873
00:38:15,570 --> 00:38:12,700
this is the boundary down here and what

874
00:38:18,060 --> 00:38:15,580
you can see is the carbon isotopic

875
00:38:21,120 --> 00:38:18,070
single that we've said my shiny is only

876
00:38:23,700 --> 00:38:21,130
one of a number of major carbon isotope

877
00:38:24,860 --> 00:38:23,710
anomalies in the early part of the

878
00:38:28,550 --> 00:38:24,870
Triassic

879
00:38:30,900 --> 00:38:28,560
looked at this great Bank of Grigio

880
00:38:33,270 --> 00:38:30,910
which is like headed here again in the

881
00:38:35,100 --> 00:38:33,280
tifus and here's some more chromatograms

882
00:38:38,210 --> 00:38:35,110
this time the standards on the top and

883
00:38:40,290 --> 00:38:38,220
these two chromatograms are for

884
00:38:42,870 --> 00:38:40,300
showing the presence of our lice are

885
00:38:44,700 --> 00:38:42,880
annoyed so actually preserved in the the

886
00:38:47,490 --> 00:38:44,710
edge of the carbonate reef system so

887
00:38:49,410 --> 00:38:47,500
several places now in the Palio

888
00:38:51,360 --> 00:38:49,420

toothless ocean we have this same signal

889
00:38:53,460 --> 00:38:51,370
at exactly the same time all of these

890
00:38:54,960 --> 00:38:53,470
places are correlated well with being at

891
00:38:59,480 --> 00:38:54,970
abounded by the presence of their

892
00:39:01,740 --> 00:38:59,490
diagnostic marine fossil india is parvis

893
00:39:03,720 --> 00:39:01,750
so what's going on the rest of the ocean

894
00:39:05,960 --> 00:39:03,730
well here's a section from Peace River

895
00:39:07,760 --> 00:39:05,970
so this is in

896
00:39:10,590 --> 00:39:07,770
Western Canada

897
00:39:13,320 --> 00:39:10,600
on the map it's roughly at this position

898
00:39:15,120 --> 00:39:13,330
here the section there's no complete

899
00:39:17,670 --> 00:39:15,130
section G observing section for the

900
00:39:20,780 --> 00:39:17,680
event but with the help of colleague

901
00:39:23,940 --> 00:39:20,790
Charles Henderson and his student we've

902
00:39:26,220 --> 00:39:23,950
been able to reconstruct a PG boundary

903
00:39:27,890 --> 00:39:26,230
section by piecing together pieces of

904
00:39:30,000 --> 00:39:27,900
different oil exploration wells because

905
00:39:32,760 --> 00:39:30,010
petroleum province that we've been

906
00:39:34,800 --> 00:39:32,770
looking through the number of cores of

907
00:39:37,770 --> 00:39:34,810
oil well of petroleum exploration wells

908
00:39:40,550 --> 00:39:37,780
and basically piece together a strategic

909
00:39:42,230 --> 00:39:40,560
fee and again being able to identify

910
00:39:52,860 --> 00:39:42,240
the

911
00:39:55,380 --> 00:39:52,870
up here and in particular I point to

912
00:39:57,030 --> 00:39:55,390
this compound here chloro bactine now

913
00:39:59,820 --> 00:39:57,040

that's the diagnosed on the diagnostic

914
00:40:02,190 --> 00:39:59,830
pigment of the green pigmented form of

915
00:40:04,680 --> 00:40:02,200
the green sulfur bacteria and these guys

916
00:40:06,600 --> 00:40:04,690
absolutely require more light than the

917
00:40:08,190 --> 00:40:06,610
brown pigmented forms and that shows

918
00:40:10,470 --> 00:40:08,200
will suggest that the water column here

919
00:40:13,530 --> 00:40:10,480
that the new zinnia was in fact that

920
00:40:16,230 --> 00:40:13,540
using his own came higher and closer to

921
00:40:18,620 --> 00:40:16,240
the surface may be as as close as 30 or

922
00:40:21,990 --> 00:40:18,630
40 meters at the surface so

923
00:40:24,890 --> 00:40:22,000
intense signal a signal for intense use

924
00:40:29,860 --> 00:40:27,760
cap stops this is a class section now

925
00:40:31,510 --> 00:40:29,870
we're going to the boreal ocean there's

926
00:40:33,340 --> 00:40:31,520
a lot of terrestrial organic matter in

927
00:40:36,910 --> 00:40:33,350
this particular section that was

928
00:40:37,950 --> 00:40:36,920
described as long ago as 1972 2-methyl

929
00:40:41,020 --> 00:40:37,960
hope pain

930
00:40:43,300 --> 00:40:41,030
biomarkers I'll just speak very briefly

931
00:40:45,250 --> 00:40:43,310
about this is it's kind of controversial

932
00:40:48,610 --> 00:40:45,260
there are potentially other sources of

933
00:40:51,310 --> 00:40:48,620
these compounds but the very high values

934
00:40:52,450 --> 00:40:51,320
that we find at my shown are part of a

935
00:40:55,570 --> 00:40:52,460
pattern that we see through the

936
00:40:58,380 --> 00:40:55,580
geological record now here are here's a

937
00:41:01,420 --> 00:40:58,390
picture of the two methyl ho pain index

938
00:41:04,170 --> 00:41:01,430

so this is representing the proportion

939
00:41:06,640 --> 00:41:04,180
of two methyl ho point ho pains as a

940
00:41:08,440 --> 00:41:06,650
fraction of all the hope annoyance and

941
00:41:10,200 --> 00:41:08,450
here we have geological time for the

942
00:41:12,250 --> 00:41:10,210
phanerozoic where the last 600 years

943
00:41:13,750 --> 00:41:12,260
most of this data is coming from

944
00:41:17,230 --> 00:41:13,760
petroleum samples that are being

945
00:41:20,200 --> 00:41:17,240
analyzed and what you can see is you get

946
00:41:24,310 --> 00:41:20,210
very high values at the late devonian

947
00:41:26,350 --> 00:41:24,320
mass extinction you get very high values

948
00:41:28,930 --> 00:41:26,360
at an oceanic anoxic event and there

949
00:41:31,030 --> 00:41:28,940
twice Ian there are several oceanic

950
00:41:32,950 --> 00:41:31,040
anoxic events in the Cretaceous they

951
00:41:34,630 --> 00:41:32,960
have high values the highest value of

952
00:41:36,540 --> 00:41:34,640
all is the one that we measured for the

953
00:41:41,880 --> 00:41:36,550
Permian Triassic section

954
00:41:46,990 --> 00:41:44,590
observation here that these particular

955
00:41:49,390 --> 00:41:47,000
biomarkers are highest when we have

956
00:41:51,370 --> 00:41:49,400
these major Oceanic and oxic events

957
00:41:54,280 --> 00:41:51,380
which have characterized by a disruption

958
00:41:56,830 --> 00:41:54,290
of the nitrogen cycle and perhaps open a

959
00:41:58,960 --> 00:41:56,840
window for a side effect or given

960
00:42:00,870 --> 00:41:58,970
advantage design of a tree that can fix

961
00:42:04,590 --> 00:42:00,880
their own nitrogen

962
00:42:07,420 --> 00:42:04,600
so state oceans they're toxic to all

963
00:42:09,760 --> 00:42:07,430

animals of course bacteria on the other

964
00:42:11,560 --> 00:42:09,770
hand can survive so when you have a

965
00:42:15,160 --> 00:42:11,570
state in an ocean you have low oxygen

966
00:42:17,580 --> 00:42:15,170
you have high P P co2 and high amounts

967
00:42:19,200 --> 00:42:17,590
of h2s and all have adverse impacts on

968
00:42:22,870 --> 00:42:19,210
desire

969
00:42:24,970 --> 00:42:22,880
in Klehr newspaper of 2005 we

970
00:42:26,800 --> 00:42:24,980
hypothesized that one of the agents of

971
00:42:28,990 --> 00:42:26,810
extinction a major agent was the spread

972
00:42:31,780 --> 00:42:29,000
of an oxygen and sulfur deep waters on

973
00:42:34,050 --> 00:42:31,790
two continental shelves and other people

974
00:42:35,630 --> 00:42:34,060
have made similar observation

975
00:42:37,780 --> 00:42:35,640
particularly

976
00:42:40,250 --> 00:42:37,790
campus done and

977
00:42:42,920 --> 00:42:40,260
his colleagues have live Arthur and

978
00:42:44,930 --> 00:42:42,930
catch and Myer they've modeled this and

979
00:42:47,030 --> 00:42:44,940
in fact if you can put sufficient

980
00:42:49,520 --> 00:42:47,040
hydrogen sulfide into the atmosphere in

981
00:42:51,890 --> 00:42:49,530
fact it could be quite long-lived

982
00:42:55,090 --> 00:42:51,900
because the mechanisms by which you can

983
00:42:57,440 --> 00:42:55,100
remove violet or hydrogen sulphite

984
00:43:01,880 --> 00:42:57,450
complex and take the significant time

985
00:43:04,190 --> 00:43:01,890
and in fact clean the atmosphere so you

986
00:43:06,980 --> 00:43:04,200
have carbon cycle operating in a

987
00:43:09,920 --> 00:43:06,990
stratified ocean and we have using water

988
00:43:11,510 --> 00:43:09,930

column and at certain times hydrogen

989
00:43:14,330 --> 00:43:11,520
sulphide evade into the atmosphere and

990
00:43:15,850 --> 00:43:14,340
pack perhaps adversely impacting the

991
00:43:19,280 --> 00:43:15,860
terrestrial biosphere

992
00:43:22,040 --> 00:43:19,290
we in fact have modern some modern

993
00:43:25,450 --> 00:43:22,050
counterparts this is a satellite image

994
00:43:27,830 --> 00:43:25,460
of water column off southern Namibia

995
00:43:29,480 --> 00:43:27,840
where it's well known that you have

996
00:43:31,700 --> 00:43:29,490
advanced of sulphide eruption that

997
00:43:34,190 --> 00:43:31,710
caused major fish cools and the sulphide

998
00:43:36,200 --> 00:43:34,200
eruption in fact it's visualized here in

999
00:43:38,480 --> 00:43:36,210
the presence of these sort of green

1000
00:43:40,360 --> 00:43:38,490
clouds these clouds here which are in

1001
00:43:43,250 --> 00:43:40,370
fact

1002
00:43:46,580 --> 00:43:43,260
elemental sulphur that's been that's

1003
00:43:48,920 --> 00:43:46,590
been formed from the basic the oxidation

1004
00:43:50,540 --> 00:43:48,930
of hydrogen sulfide and of course the

1005
00:43:52,610 --> 00:43:50,550
other very well-known example is the

1006
00:43:55,600 --> 00:43:52,620
dead zone that we see in the Gulf of

1007
00:43:57,590 --> 00:43:55,610
Mexico caused by

1008
00:43:59,270 --> 00:43:57,600
agricultural pollution coming down the

1009
00:44:02,060 --> 00:43:59,280
Mississippi Mississippi River and of

1010
00:44:04,760 --> 00:44:02,070
course the dead zone again the demise of

1011
00:44:07,460 --> 00:44:04,770
fish and other organisms driven by high

1012
00:44:10,310 --> 00:44:07,470
concentrations of hydrogen sulfide so to

1013
00:44:11,900 --> 00:44:10,320

summarize everything hydrogen sulfide in

1014
00:44:14,600 --> 00:44:11,910
the ocean atmosphere would be toxic to

1015
00:44:16,180 --> 00:44:14,610
all but bacterial life understanding the

1016
00:44:19,490 --> 00:44:16,190
causes of this

1017
00:44:22,190 --> 00:44:19,500
complex realm of causality I think can

1018
00:44:24,130 --> 00:44:22,200
be connected to the long time scale of

1019
00:44:27,020 --> 00:44:24,140
this event I

1020
00:44:29,180 --> 00:44:27,030
think it's related to the aggregation of

1021
00:44:30,740 --> 00:44:29,190
the supercontinent pangaea in a

1022
00:44:32,780 --> 00:44:30,750
greenhouse world when you have a

1023
00:44:35,000 --> 00:44:32,790
greenhouse world you have a low equator

1024
00:44:36,670 --> 00:44:35,010
to pole temperature differential and

1025
00:44:40,250 --> 00:44:36,680
that

1026
00:44:41,870 --> 00:44:40,260
helps the ocean circulation to be very

1027
00:44:44,710 --> 00:44:41,880
sluggish in fact much more sluggish than

1028
00:44:47,720 --> 00:44:44,720
today when we have ice at the poles

1029
00:44:50,359 --> 00:44:47,730
the uplift associated with the eight

1030
00:44:52,220 --> 00:44:50,369
aggregation could leave the massive

1031
00:44:54,190 --> 00:44:52,230
weathering of the Paleozoic coals and

1032
00:44:57,590 --> 00:44:54,200
this would draw down oxygen

1033
00:44:59,510 --> 00:44:57,600
elevate co2 and the organic matter

1034
00:45:00,940 --> 00:44:59,520
transfer to the ocean could in fact

1035
00:45:04,099 --> 00:45:00,950
provide

1036
00:45:06,590 --> 00:45:04,109
source of food for sulfate reduction by

1037
00:45:08,960 --> 00:45:06,600
sulfate reducing bacteria a tectonic

1038
00:45:12,170 --> 00:45:08,970

underpinning of the event councilor the

1039
00:45:14,270 --> 00:45:12,180
delay in the recovery use in here waxes

1040
00:45:16,390 --> 00:45:14,280
and wanes the long time is needed to

1041
00:45:19,060 --> 00:45:16,400
really better leave the ocean I

1042
00:45:21,490 --> 00:45:19,070
think it also accounts for

1043
00:45:24,020 --> 00:45:21,500
repeated carbon-13

1044
00:45:27,050 --> 00:45:24,030
excursions but also the different pace

1045
00:45:28,550 --> 00:45:27,060
and and and scale of the excursions at

1046
00:45:31,520 --> 00:45:28,560
the different locations where it's been

1047
00:45:33,170 --> 00:45:31,530
measured and the biological consequences

1048
00:45:35,780 --> 00:45:33,180
of course could have been made worse by

1049
00:45:37,790 --> 00:45:35,790
the intense volcanism that occurred near

1050
00:45:39,950 --> 00:45:37,800
to the boundary but we can see from the

1051
00:45:42,740 --> 00:45:39,960
you Xenia or the seal for using here

1052
00:45:46,810 --> 00:45:42,750
this event had it was precise by a long

1053
00:45:52,220 --> 00:45:48,400
and

1054
00:45:54,109 --> 00:45:52,230
in fact if you look closely at this at

1055
00:45:57,220 --> 00:45:54,119
this particular figure here from one of

1056
00:46:00,440 --> 00:45:57,230
anti-north papers you can in fact see

1057
00:46:03,230 --> 00:46:00,450
there is in fact an extinction end of

1058
00:46:05,690 --> 00:46:03,240
the meal Permian and there's a continued

1059
00:46:08,120 --> 00:46:05,700
loss of biodiversity so it may be a

1060
00:46:09,800 --> 00:46:08,130
sudden event at the boundary itself but

1061
00:46:11,690 --> 00:46:09,810
you can see in fact the significant loss

1062
00:46:14,290 --> 00:46:11,700
of biodiversity leading up to the lane

1063
00:46:19,340 --> 00:46:14,300

extension of it

1064
00:46:22,940 --> 00:46:19,350
and one more I think ah yes acknowledge

1065
00:46:24,650 --> 00:46:22,950
my colleagues particularly Darwin and

1066
00:46:26,050 --> 00:46:24,660
professor Jinyoung gana who had the

1067
00:46:29,200 --> 00:46:26,060
foresight to

1068
00:46:32,450 --> 00:46:29,210
study this event that's so well

1069
00:46:35,630 --> 00:46:32,460
documented now at my show China and the

1070
00:46:38,230 --> 00:46:35,640
people who did all the hard work for

1071
00:46:40,849 --> 00:46:38,240
sampling the corner and one of the

1072
00:46:42,779 --> 00:46:40,859
analytical work church in June he was

1073
00:46:45,870 --> 00:46:42,789
assisted

1074
00:46:48,659 --> 00:46:45,880
in fact guided to eliza degree by my i

1075
00:46:51,479 --> 00:46:48,669
could call it gordon love and other

1076
00:46:53,249 --> 00:46:51,489
sections have been studied by clearly

1077
00:46:55,319 --> 00:46:53,259
price of course western australia mimsey

1078
00:46:56,870 --> 00:46:55,329
hayes is doing the work at MIT now and

1079
00:46:59,159 --> 00:46:56,880
in fact

1080
00:47:02,099 --> 00:46:59,169
immigration from his now Geoscience

1081
00:47:03,929 --> 00:47:02,109
Australia work from the beginning to set

1082
00:47:04,849 --> 00:47:03,939
up the laboratory so we could in fact do

1083
00:47:09,040 --> 00:47:04,859
this work

1084
00:47:15,319 --> 00:47:09,050
and Thank You

1085
00:47:17,849 --> 00:47:15,329
[Applause]

1086
00:47:20,819 --> 00:47:17,859
Roger thank you very much for a great

1087
00:47:23,130 --> 00:47:20,829
talk will open it up for questions now

1088
00:47:25,409 --> 00:47:23,140

so if you have a question please raise

1089
00:47:29,130 --> 00:47:25,419
your hand in WebEx and I'll give you

1090
00:47:32,279 --> 00:47:29,140
just a second to do that this is the

1091
00:47:34,319 --> 00:47:32,289
last director seminar of this calendar

1092
00:47:37,549 --> 00:47:34,329
year normally we'd pick up director

1093
00:47:40,079 --> 00:47:37,559
seminars again at the end of January I

1094
00:47:42,419 --> 00:47:40,089
think we're probably going to delay it a

1095
00:47:44,479 --> 00:47:42,429
couple of months because we're going to

1096
00:47:47,819 --> 00:47:44,489
have a series of

1097
00:47:50,489 --> 00:47:47,829
videocast seminars by all the 14

1098
00:47:51,659 --> 00:47:50,499
principal investigators in the Institute

1099
00:47:53,309 --> 00:47:51,669
and I should have mentioned in

1100
00:47:55,679 --> 00:47:53,319
introducing Roger of course that he is a

1101
00:47:58,429 --> 00:47:55,689
principal investigator of our MIT team

1102
00:48:01,589 --> 00:47:58,439
where he's focused on an earlier period

1103
00:48:04,949 --> 00:48:01,599
in Earth's biological history and that

1104
00:48:08,219 --> 00:48:04,959
is the development of complexity in the

1105
00:48:14,179 --> 00:48:08,229
Proterozoic so marco do we have any

1106
00:48:19,439 --> 00:48:16,859
hello everybody the lunar Science

1107
00:48:21,029 --> 00:48:19,449
Institute is very happy to be a part of

1108
00:48:23,399 --> 00:48:21,039
this discussion now

1109
00:48:25,549 --> 00:48:23,409
Roger that was great I wonder if I could

1110
00:48:28,289 --> 00:48:25,559
just ask you to say a little more about

1111
00:48:31,169 --> 00:48:28,299
the possible role of volcanism or

1112
00:48:34,289 --> 00:48:31,179
whatever was precipitous that that ended

1113
00:48:39,229 --> 00:48:34,299

this what triggered the final event

1114
00:48:45,799 --> 00:48:41,630
well I think

1115
00:48:51,810 --> 00:48:48,659
to define the exact role of the

1116
00:48:54,150 --> 00:48:51,820
volcanism because one set of organism Li

1117
00:48:56,370 --> 00:48:54,160
at the time of the onset of volcanism is

1118
00:48:58,770 --> 00:48:56,380
not precise precisely known as the

1119
00:48:59,900 --> 00:48:58,780
boundary of itself so when you have a

1120
00:49:03,750 --> 00:48:59,910
major

1121
00:49:05,720 --> 00:49:03,760
tectonic episode of like aggregation of

1122
00:49:08,490 --> 00:49:05,730
Pangaea of course you're going to have

1123
00:49:10,260 --> 00:49:08,500
volcanism associated with it but the

1124
00:49:12,330 --> 00:49:10,270
timing I think is critical and I know

1125
00:49:15,840 --> 00:49:12,340
there are a number of people trying to

1126
00:49:17,610 --> 00:49:15,850
to date that the Siberian traps and the

1127
00:49:19,380 --> 00:49:17,620
onset of the Siberian traps much more

1128
00:49:21,600 --> 00:49:19,390
precisely and I think at that point we

1129
00:49:23,850 --> 00:49:21,610
be able to say more clearly what the

1130
00:49:27,860 --> 00:49:23,860
role of that event was in the massive

1131
00:49:33,200 --> 00:49:31,220
that's the best I can do Kentucky

1132
00:49:36,620 --> 00:49:33,210
thanks

1133
00:49:39,530 --> 00:49:36,630
okay we have a question at a m--

1134
00:49:41,940 --> 00:49:39,540
hi Roger is Dave here

1135
00:49:43,770 --> 00:49:41,950
sort of a related mechanism which

1136
00:49:47,700 --> 00:49:43,780
Khorsandi Noll talked about was this

1137
00:49:49,320 --> 00:49:47,710
idea about co2 high levels of co2 and I

1138
00:49:52,650 --> 00:49:49,330

guess related to that also might be

1139
00:49:55,500 --> 00:49:52,660
ocean pH and is there any handle you

1140
00:49:57,510 --> 00:49:55,510
could didn't conceive of how you might

1141
00:49:59,040 --> 00:49:57,520
expect for example a drop of pH and the

1142
00:50:01,110 --> 00:49:59,050
shallow waters which obviously would be

1143
00:50:02,910 --> 00:50:01,120
bad for Shelly creatures do you think

1144
00:50:06,050 --> 00:50:02,920
there's any hope to try to constrain

1145
00:50:09,710 --> 00:50:06,060
sort of co2 / pH associated with this

1146
00:50:14,970 --> 00:50:13,410
I hope I made it clear though I think

1147
00:50:17,670 --> 00:50:14,980
they're all part of the same package you

1148
00:50:19,500 --> 00:50:17,680
won't have you won't have used any air

1149
00:50:20,820 --> 00:50:19,510
unless you've got an toxic ocean and

1150
00:50:23,340 --> 00:50:20,830
then you're going to have high

1151
00:50:26,120 --> 00:50:23,350
concentrations of co2 you can have low

1152
00:50:27,770 --> 00:50:26,130
pH it's in fact a toxic mix

1153
00:50:30,840 --> 00:50:27,780
and

1154
00:50:32,540 --> 00:50:30,850
certainly Andy has demonstrated that the

1155
00:50:36,060 --> 00:50:32,550
the

1156
00:50:38,040 --> 00:50:36,070
that particular tax are vulnerable some

1157
00:50:41,010 --> 00:50:38,050
protect acts are less vulnerable and and

1158
00:50:44,370 --> 00:50:41,020
the the degree to which there they are

1159
00:50:46,070 --> 00:50:44,380
lost is in accord with the idea that

1160
00:50:49,890 --> 00:50:46,080
that

1161
00:50:52,370 --> 00:50:49,900
sea pco2 is in play is playing an

1162
00:50:55,940 --> 00:50:52,380
important part but what

1163
00:50:58,800 --> 00:50:55,950

intrigues me is the strange

1164
00:51:01,440 --> 00:50:58,810
events in the terrestrial biosphere that

1165
00:51:04,359 --> 00:51:01,450
suggests it's not just co2 in the

1166
00:51:06,940 --> 00:51:04,369
atmosphere that's having an effect on

1167
00:51:09,390 --> 00:51:06,950
the plants because my colleague Clinton

1168
00:51:11,980 --> 00:51:09,400
Foster is in fact documented

1169
00:51:13,109 --> 00:51:11,990
some very strange effects on plant

1170
00:51:15,730 --> 00:51:13,119
pollen

1171
00:51:18,280 --> 00:51:15,740
it's very hard to understand how

1172
00:51:22,000 --> 00:51:18,290
increased atmospheric co2 could cause

1173
00:51:24,760 --> 00:51:22,010
such a dramatic change in the in the in

1174
00:51:26,380 --> 00:51:24,770
the plant world so I think there's

1175
00:51:28,770 --> 00:51:26,390
reason to think that there's something

1176
00:51:31,930 --> 00:51:28,780
else that's toxic in the atmosphere and

1177
00:51:34,630 --> 00:51:31,940
hydrogen sulfide is a likely candidate

1178
00:51:39,460 --> 00:51:34,640
so it's certainly a mixed a toxic mix

1179
00:51:41,440 --> 00:51:39,470
and certainly low pH is going to heavily

1180
00:51:44,890 --> 00:51:41,450
constrain or any organism that relies on

1181
00:51:48,670 --> 00:51:44,900
the carbonate skeleton but something has

1182
00:51:50,250 --> 00:51:48,680
to be causing the loss of diversity in

1183
00:51:53,920 --> 00:51:50,260
the plant world and

1184
00:51:55,300 --> 00:51:53,930
since we commonly taught that co2 is in

1185
00:51:57,849 --> 00:51:55,310
fact some kind of fertilize it would

1186
00:52:00,609 --> 00:51:57,859
require enormous increase in co2 in the

1187
00:52:06,660 --> 00:52:00,619
atmosphere I think to add so adversely

1188
00:52:11,320 --> 00:52:08,880

University of Washington

1189
00:52:13,359 --> 00:52:11,330
yeah this is Sean Goldman at the

1190
00:52:15,609 --> 00:52:13,369
University of Washington my question is

1191
00:52:17,230 --> 00:52:15,619
how can we be sure that the certain

1192
00:52:19,960 --> 00:52:17,240
color pigments have always been

1193
00:52:21,490 --> 00:52:19,970
associated with the sulfur metabolic

1194
00:52:23,050 --> 00:52:21,500
pathways that they're associated with in

1195
00:52:24,730 --> 00:52:23,060
the modern environment and that may be

1196
00:52:27,220 --> 00:52:24,740
the the correlation between those two

1197
00:52:31,800 --> 00:52:27,230
things hasn't evolved as the oxidation

1198
00:52:40,839 --> 00:52:36,480
that's a question I'm often asked

1199
00:52:42,839 --> 00:52:40,849
all I can say in response is that the

1200
00:52:45,510 --> 00:52:42,849
biosynthetic pathways

1201
00:52:49,440 --> 00:52:45,520
leading to lipids

1202
00:52:49,450 --> 00:52:55,020
constrained to particular organisms

1203
00:52:59,500 --> 00:52:56,430
[Music]

1204
00:53:01,480 --> 00:52:59,510
there's no evidence well there's no

1205
00:53:04,300 --> 00:53:01,490
evidence that those specific pigments

1206
00:53:07,300 --> 00:53:04,310
are found in any other taxa other than

1207
00:53:09,850 --> 00:53:07,310
the sulfur bacteria aromatic carotenoids

1208
00:53:12,280 --> 00:53:09,860
have been recently found in some cider

1209
00:53:15,040 --> 00:53:12,290
bacterium but they're different

1210
00:53:16,500 --> 00:53:15,050
compounds and they're not likely to be

1211
00:53:19,390 --> 00:53:16,510
confused with the ones that I've shot

1212
00:53:22,510 --> 00:53:19,400
also we have a record of these pigments

1213
00:53:25,270 --> 00:53:22,520

a continuous record of their currency in

1214
00:53:26,830 --> 00:53:25,280
sediments not just at oceanic anoxic

1215
00:53:28,390 --> 00:53:26,840
events but in particularly environments

1216
00:53:30,460 --> 00:53:28,400
where we have stratified Warner columns

1217
00:53:33,550 --> 00:53:30,470
and other evidence of soul feeding water

1218
00:53:34,600 --> 00:53:33,560
columns so they're not just found this

1219
00:53:37,810 --> 00:53:34,610
event they're found through the

1220
00:53:39,780 --> 00:53:37,820
geological record always found alongside

1221
00:53:41,950 --> 00:53:39,790
other evidence for soft fatigue

1222
00:53:45,310 --> 00:53:41,960
conditions and the record goes back

1223
00:53:47,440 --> 00:53:45,320
quite definitely my former student

1224
00:53:50,020 --> 00:53:47,450
Auckland Roxas signed very nicely that

1225
00:53:51,940 --> 00:53:50,030
in the mezzo Proterozoic MacArthur basin

1226
00:53:54,760 --> 00:53:51,950
we can find evidence for both the green

1227
00:53:57,670 --> 00:53:54,770
and the purple sulfur bacteria so a

1228
00:53:59,650 --> 00:53:57,680
continuous geological record occurrence

1229
00:54:02,080 --> 00:53:59,660
in modern organisms and phanerozoic

1230
00:54:03,420 --> 00:54:02,090
sediments in associated with geological

1231
00:54:05,530 --> 00:54:03,430
evidence for those particular

1232
00:54:07,630 --> 00:54:05,540
physiological conditions required by the

1233
00:54:09,490 --> 00:54:07,640
organism I think that's very compelling

1234
00:54:11,230 --> 00:54:09,500
evidence that these organisms have been

1235
00:54:13,740 --> 00:54:11,240
making these same compounds for the same

1236
00:54:16,810 --> 00:54:13,750
purpose ever since they were invented so

1237
00:54:19,480 --> 00:54:16,820
in short you often find them correlated

1238
00:54:20,950 --> 00:54:19,490

with separate evidence for those oceanic

1239
00:54:24,520 --> 00:54:20,960
conditions or those water column

1240
00:54:26,890 --> 00:54:24,530
conditions yes in fact they occur in

1241
00:54:30,300 --> 00:54:26,900
many kinds of oil usually associated

1242
00:54:32,650 --> 00:54:30,310
with salt and salt of course is using

1243
00:54:36,550 --> 00:54:32,660
associated with some kind of water

1244
00:54:39,610 --> 00:54:36,560
column stratification so the oil fields

1245
00:54:41,500 --> 00:54:39,620
in the oil in Australia there's oil in

1246
00:54:43,570 --> 00:54:41,510
Canada in particular soil in the middle

1247
00:54:45,220 --> 00:54:43,580
of Middle East there's oil in Florida

1248
00:54:47,230 --> 00:54:45,230
there's oil in the Gulf of Mexico they

1249
00:54:49,240 --> 00:54:47,240
have these compounds and they usually a

1250
00:54:51,940 --> 00:54:49,250
state associated with stratigraphic

1251
00:54:53,700 --> 00:54:51,950
layers that have all the hallmarks of

1252
00:54:56,590 --> 00:54:53,710
being an evaporative system and

1253
00:54:58,480 --> 00:54:56,600
evaporative system of course you the

1254
00:55:00,580 --> 00:54:58,490
curse of the precipitate carbonate the

1255
00:55:03,040 --> 00:55:00,590
second or you precipitate the gypsum you

1256
00:55:05,380 --> 00:55:03,050
have mechanism to keep the water column

1257
00:55:07,570 --> 00:55:05,390
stratified and under those conditions

1258
00:55:10,560 --> 00:55:07,580
that's when you find the green sulfur

1259
00:55:15,690 --> 00:55:10,570
bacteria penetrated

1260
00:55:18,130 --> 00:55:15,700
is that yes thank you

1261
00:55:19,810 --> 00:55:18,140
Roger no one has their hand raised right

1262
00:55:22,000 --> 00:55:19,820
now in WebEx so I'll take the

1263
00:55:25,089 --> 00:55:22,010

opportunity to ask a question could you

1264
00:55:28,830 --> 00:55:25,099
say a bit more about how global these

1265
00:55:31,660 --> 00:55:28,840
youth enik conditions were likely to be

1266
00:55:34,150 --> 00:55:31,670
particularly if this was associated with

1267
00:55:36,450 --> 00:55:34,160
the aggregation of Pangea and of course

1268
00:55:40,150 --> 00:55:36,460
all of your samples are of necessity

1269
00:55:42,820 --> 00:55:40,160
from parts of Pangea you have the rest

1270
00:55:44,980 --> 00:55:42,830
of the global ocean and we're they're

1271
00:55:46,839 --> 00:55:44,990
likely to be used in ik conditions

1272
00:55:50,339 --> 00:55:46,849
throughout the rest of the global ocean

1273
00:55:53,349 --> 00:55:50,349
or could there have been oxygen Oasis

1274
00:55:56,040 --> 00:55:53,359
perhaps extensive ones across the rest

1275
00:55:59,520 --> 00:55:56,050
of the globe yes that's a

1276
00:56:02,620 --> 00:55:59,530
very perceptive call and

1277
00:56:05,380 --> 00:56:02,630
of course the only parts of the ocean

1278
00:56:08,620 --> 00:56:05,390
that are preserved are the bits of

1279
00:56:13,720 --> 00:56:08,630
continental margins as you know the the

1280
00:56:15,520 --> 00:56:13,730
ocean crust is in the main subducted and

1281
00:56:17,740 --> 00:56:15,530
lost from the geological record so

1282
00:56:21,570 --> 00:56:17,750
basically we have a record of of the

1283
00:56:26,790 --> 00:56:21,580
ocean along the edges of continents

1284
00:56:29,859 --> 00:56:26,800
is the sake has in fact done a study of

1285
00:56:32,370 --> 00:56:29,869
some oceanic sediments that are

1286
00:56:34,990 --> 00:56:32,380
preserved in Japan as far as I'm aware

1287
00:56:38,710 --> 00:56:35,000
they could be the only ones of this

1288
00:56:41,650 --> 00:56:38,720

event but what he noticed was dramatic

1289
00:56:43,560 --> 00:56:41,660
changes in with ology at this event as

1290
00:56:47,620 --> 00:56:43,570
recorded in these

1291
00:56:50,310 --> 00:56:47,630
marine charts and again he interprets

1292
00:56:54,040 --> 00:56:50,320
that in terms of this being a

1293
00:56:55,750 --> 00:56:54,050
major and oxidant equals in fact a super

1294
00:56:58,030 --> 00:56:55,760
anoxic event so from the one example

1295
00:57:00,690 --> 00:56:58,040
that I know where we have a mid-ocean

1296
00:57:03,609 --> 00:57:00,700
sediment preserved

1297
00:57:06,190 --> 00:57:03,619
the evidence it is in fact quite

1298
00:57:08,530 --> 00:57:06,200
distinctive in its own right and and

1299
00:57:11,140 --> 00:57:08,540
interpreted as evidence that the ocean

1300
00:57:17,469 --> 00:57:11,150
that the mid-ocean at least represented

1301
00:57:24,739 --> 00:57:22,430
thank you it'sa sake who worked on the

1302
00:57:27,259 --> 00:57:24,749
section in Japan unfortunately it's too

1303
00:57:28,819 --> 00:57:27,269
cooked to do any biomarker study so that

1304
00:57:30,499 --> 00:57:28,829
there's have been very highly

1305
00:57:33,799 --> 00:57:30,509
metamorphose and are not suitable for

1306
00:57:36,829 --> 00:57:33,809
the sorts of things we do but he is in

1307
00:57:39,739 --> 00:57:36,839
fact proponent the hypothesis that this

1308
00:57:41,359 --> 00:57:39,749
is event that started in the in fact in

1309
00:57:43,489 --> 00:57:41,369
the middle of the Permian that is not

1310
00:57:45,079 --> 00:57:43,499
just one of them reflect at the end of

1311
00:57:47,509 --> 00:57:45,089
the Permian but something that has a

1312
00:57:51,099 --> 00:57:47,519
long gestation and our evidence today

1313
00:57:59,109 --> 00:57:54,459

can I ask a follow-up question

1314
00:58:01,910 --> 00:57:59,119
go ahead David okay Morrison again

1315
00:58:04,130 --> 00:58:01,920
just from the fact of this severe mass

1316
00:58:06,469 --> 00:58:04,140
extinction doesn't that tell you

1317
00:58:10,099 --> 00:58:06,479
something about the unlikelihood of

1318
00:58:12,140 --> 00:58:10,109
having an oxygen ik ocean out there to

1319
00:58:19,269 --> 00:58:12,150
preserve species that that apparently

1320
00:58:27,170 --> 00:58:23,689
if this event were limited to the two

1321
00:58:30,069 --> 00:58:27,180
Pangaea and the Neo tothis ocean in that

1322
00:58:33,109 --> 00:58:30,079
area and the rest of the great ocean

1323
00:58:36,759 --> 00:58:33,119
survived wouldn't we have not seen a

1324
00:58:39,049 --> 00:58:36,769
mass extinction of this level

1325
00:58:40,759 --> 00:58:39,059
we've got at least two sites on the

1326
00:58:43,180 --> 00:58:40,769
panthalassic ocean

1327
00:58:45,709 --> 00:58:43,190
we've tried looking further south

1328
00:58:49,039 --> 00:58:45,719
the sediments of california but they're

1329
00:58:50,359 --> 00:58:49,049
in fact - cool so where we can find as

1330
00:58:52,309 --> 00:58:50,369
far as i'm aware - looking at the

1331
00:58:54,709 --> 00:58:52,319
northern part of a painful painful icy

1332
00:58:58,609 --> 00:58:54,719
ocean but the two places we've looked at

1333
00:58:59,930 --> 00:58:58,619
both show evidences use in here so that

1334
00:59:02,539 --> 00:58:59,940
that's the best we can do at the moment

1335
00:59:04,699 --> 00:59:02,549
I think we have evidence that the two

1336
00:59:06,609 --> 00:59:04,709
major oceans as well as the boreal ocean

1337
00:59:09,890 --> 00:59:06,619
in a narrow Seaway

1338
00:59:11,539 --> 00:59:09,900

use any and we haven't yet found any

1339
00:59:14,420 --> 00:59:11,549
expression of this event that doesn't

1340
00:59:15,410 --> 00:59:14,430
show expression of use in here so it's I

1341
00:59:16,819 --> 00:59:15,420
think it's pretty compelling case

1342
00:59:20,630 --> 00:59:16,829
there's in fact there's we have eight

1343
00:59:22,819 --> 00:59:20,640
sites and I don't know if you need more

1344
00:59:25,660 --> 00:59:22,829
than eight but I like I find this pretty

1345
00:59:25,670 --> 00:59:30,010
but if we have to

1346
00:59:34,990 --> 00:59:32,800
do we have any other questions if you do

1347
00:59:37,660 --> 00:59:35,000
you can just open your mic and chime on

1348
00:59:39,360 --> 00:59:37,670
in you can email me yeah I think Marcus

1349
00:59:41,620 --> 00:59:39,370
came to have the room back

1350
00:59:45,880 --> 00:59:41,630
[Music]

1351
00:59:47,910 --> 00:59:45,890
Rogers yep this is Marilyn Bogle at at

1352
00:59:52,060 --> 00:59:47,920
Ames

1353
00:59:54,220 --> 00:59:52,070
I'm wondering about your interpretations

1354
00:59:56,010 --> 00:59:54,230
of the arrow isoprenoids I mean

1355
00:59:59,410 --> 00:59:56,020
obviously you have a

1356
01:00:03,220 --> 00:59:59,420
complex web of evidence of the anoxia

1357
01:00:06,190 --> 01:00:03,230
but isn't it well how do you interpret

1358
01:00:08,830 --> 01:00:06,200
arrow isoprenoids in the absence of ISO

1359
01:00:12,160 --> 01:00:08,840
Renier attained precursors because can't

1360
01:00:14,100 --> 01:00:12,170
they come from beta-carotene and sort of

1361
01:00:16,180 --> 01:00:14,110
what are your rules of thumb about

1362
01:00:19,000 --> 01:00:16,190
whether or not you could distinguish

1363
01:00:20,940 --> 01:00:19,010

those two sources my rule of thumb is

1364
01:00:26,700 --> 01:00:20,950
that

1365
01:00:33,160 --> 01:00:29,260
an isotopic evidence is entirely

1366
01:00:35,109 --> 01:00:33,170
consistent with that and as I showed a 5

1367
01:00:37,690 --> 01:00:35,119
of the 8 we have the presence of the

1368
01:00:39,580 --> 01:00:37,700
intact c40 compounds so I don't think

1369
01:00:41,410 --> 01:00:39,590
there's any doubt about their origin

1370
01:00:44,460 --> 01:00:41,420
original origin from their aromatic

1371
01:00:46,540 --> 01:00:44,470
carotenoids I

1372
01:00:48,670 --> 01:00:46,550
don't I don't personally don't think

1373
01:00:50,920 --> 01:00:48,680
that that the idea that it comes from B

1374
01:00:52,800 --> 01:00:50,930
to carotene that carries must wait at

1375
01:00:55,390 --> 01:00:52,810
all

1376
01:00:58,540 --> 01:00:55,400
ok it sounds like we should thank our

1377
01:00:58,550 --> 01:01:02,920
[Applause]

1378
01:01:08,539 --> 01:01:06,589
and please everybody tune in again when

1379
01:01:10,339 --> 01:01:08,549
these talks resume next year and as I

1380
01:01:12,199 --> 01:01:10,349
mentioned they're going to resume with a

1381
01:01:13,969 --> 01:01:12,209
series of talks actually we're going to

1382
01:01:16,670 --> 01:01:13,979
do in probably two per week starting in

1383
01:01:18,620 --> 01:01:16,680
early February with all of the NAI

1384
01:01:20,449 --> 01:01:18,630
principal investigators presenting

1385
01:01:23,180 --> 01:01:20,459
seminars over the course of about seven