EARTH-LIFE
SCIENCE
INSTITUTE

Yuichiro Ueno

Redox buffering of Archean atmosphere

1
00:00:00,160 --> 00:00:13,959
[Music]

2
00:00:21,500 --> 00:00:18,529
kennefa and good afternoon um I rec to

3
00:00:25,130 --> 00:00:21,510
talk about the early environment of the

4
00:00:30,320 --> 00:00:25,140
earth particularly focusing on the time

5
00:00:33,770 --> 00:00:30,330
period code akhiyan so first of all what

6
00:00:37,600 --> 00:00:33,780
is a Kian again is the time field from

7
00:00:41,540 --> 00:00:37,610
four billion to 2.5 billion years ago

8
00:00:45,830 --> 00:00:41,550
where when the the earth's surface is

9
00:00:49,639 --> 00:00:45,840
and totally covered by water and with no

10
00:00:54,920 --> 00:00:49,649
continent on only small volcanic islands

11
00:00:57,110 --> 00:00:54,930
and the higher heat works of this age

12
00:01:00,260 --> 00:00:57,120
and we believe that the volcanic

13
00:01:02,270 --> 00:01:00,270

activity was higher than today and so

14
00:01:05,240 --> 00:01:02,280
the hydrothermal activity is also higher

15
00:01:08,600 --> 00:01:05,250
than today's but the surface

16
00:01:10,870 --> 00:01:08,610
temperatures very controversial many

17
00:01:14,109 --> 00:01:10,880
people be with this period is hot

18
00:01:18,640 --> 00:01:14,119
horizontally but not social and

19
00:01:21,499 --> 00:01:18,650
biosphere is dominated by prokaryote and

20
00:01:24,200 --> 00:01:21,509
because the onset of oxygenic

21
00:01:27,499 --> 00:01:24,210
photosynthesis and adam of theories be

22
00:01:32,569 --> 00:01:27,509
able to have been free from molecular

23
00:01:36,649 --> 00:01:32,579
oxygen instead the geology textbook said

24
00:01:42,760 --> 00:01:36,659
you know co2 as a main component of the

25
00:01:46,249 --> 00:01:42,770
atmosphere along with maybe nitrogen but

26
00:01:49,789 --> 00:01:46,259
the current did quantitative estimate of

27
00:01:52,249 --> 00:01:49,799
the co2 levels as to a model debate how

28
00:01:55,520 --> 00:01:52,259
much co2 is there we don't know yet and

29
00:01:57,590 --> 00:01:55,530
of course the other a lot of the other

30
00:02:07,999 --> 00:01:57,600
gaseous species in the atmosphere is

31
00:02:12,350 --> 00:02:08,009
largely unknown so I'd like to focus on

32
00:02:13,690 --> 00:02:12,360
the three questions in my talk today and

33
00:02:19,509 --> 00:02:13,700
how much

34
00:02:24,130 --> 00:02:19,519
alchy unanimously and more broadly

35
00:02:26,740 --> 00:02:24,140
speaking how and on what control the

36
00:02:29,770 --> 00:02:26,750
lyrics state-of-the-art Ian Artemis's

37
00:02:34,240 --> 00:02:29,780
and chemistry atmosphere is very

38
00:02:39,880 --> 00:02:34,250

important also for climate through the

39
00:02:42,220 --> 00:02:39,890
greenhouse effect so finally I talked

40
00:02:47,850 --> 00:02:42,230
about the link between the uttermost

41
00:02:50,470 --> 00:02:47,860
chemistry and climate so I like this

42
00:02:54,430 --> 00:02:50,480
simpleton poster you know Brian man

43
00:02:59,979 --> 00:02:54,440
touching and to see the shape of

44
00:03:05,350 --> 00:02:59,989
elephant and so my talk is a I am one of

45
00:03:07,900 --> 00:03:05,360
these blind person so and to understand

46
00:03:10,780 --> 00:03:07,910
trying to understand the atmospheric

47
00:03:17,319 --> 00:03:10,790
chemistry of the pastors and my favorite

48
00:03:20,190 --> 00:03:17,329
too is stable so for isotopes this is

49
00:03:23,770 --> 00:03:20,200
very tricky because we don't know a

50
00:03:27,910 --> 00:03:23,780
direct sample of the key and atmosphere

51
00:03:32,199 --> 00:03:27,920
that's why indirectly we are trying to

52
00:03:36,970 --> 00:03:32,209
estimate or study the chemistry of the

53
00:03:41,319 --> 00:03:36,980
past atmosphere and and the surfer has

54
00:03:46,170 --> 00:03:41,329
four stables of isotopes service 32 33

55
00:03:50,800 --> 00:03:46,180
34 and 36 and the abundance of these

56
00:03:55,170 --> 00:03:50,810
isotopes for example 34 as is 4.2 1

57
00:03:57,520 --> 00:03:55,180
percent and textbook but in reality this

58
00:04:05,849 --> 00:03:57,530
abundance had changed sometimes these

59
00:04:08,229 --> 00:04:05,859
numbers not to 4.2 1 but sometimes 4.23

60
00:04:11,409 --> 00:04:08,239
or something a little bit changed

61
00:04:14,949 --> 00:04:11,419
through physical process chemical

62
00:04:17,229 --> 00:04:14,959
process or biological process and in

63
00:04:20,440 --> 00:04:17,239

that case and the indictment factor of

64
00:04:23,020 --> 00:04:20,450
surface artistry as compared to the most

65
00:04:26,620 --> 00:04:23,030
abundant sagittarius is about half of

66
00:04:29,070 --> 00:04:26,630
that of 34 s this is a golden do

67
00:04:33,000 --> 00:04:29,080
it's based in the quantum mechanics that

68
00:04:39,880 --> 00:04:33,010
we call this a must dependent relations

69
00:04:42,370 --> 00:04:39,890
but a few exception exception I of the

70
00:04:47,020 --> 00:04:42,380
photochemistry a few thousand for the

71
00:04:49,740 --> 00:04:47,030
chemistry in the gas phase reaction do

72
00:04:52,810 --> 00:04:49,750
not always this blue so that's why that

73
00:04:56,290 --> 00:04:52,820
deviation from this mass dependent

74
00:05:00,460 --> 00:04:56,300
relationship we define the deviation

75
00:05:03,760 --> 00:05:00,470
from relationship as kappa delta value

76
00:05:08,200 --> 00:05:03,770
as a non video captured over is a sign

77
00:05:12,250 --> 00:05:08,210
something help happening in the

78
00:05:14,620 --> 00:05:12,260
atmosphere atmospheric chemistry and the

79
00:05:19,440 --> 00:05:14,630
signal can be brought into the servant

80
00:05:23,980 --> 00:05:19,450
and about more than fifteen years ago

81
00:05:28,410 --> 00:05:23,990
the foie gras arrow first found the this

82
00:05:31,770 --> 00:05:28,420
sort of isotopic anomaly from the

83
00:05:37,240 --> 00:05:31,780
geologic samples particularly older than

84
00:05:39,580 --> 00:05:37,250
2.3 billion years ago so this isotopic

85
00:05:43,150 --> 00:05:39,590
anomalies produce known to be produced

86
00:05:47,470 --> 00:05:43,160
by the photodissociation reaction of so2

87
00:05:51,010 --> 00:05:47,480
very very exceptional and preserved in

88
00:05:53,470 --> 00:05:51,020

sediment is atmospheric anoxic are free

89
00:05:56,620 --> 00:05:53,480
from oxygen because the the cell for

90
00:06:00,880 --> 00:05:56,630
entering into the atmosphere as a form

91
00:06:04,510 --> 00:06:00,890
of so2 and are normally eating reaction

92
00:06:08,560 --> 00:06:04,520
is removal of this oxygen and making s

93
00:06:13,960 --> 00:06:08,570
oh this is responsible to make this

94
00:06:17,710 --> 00:06:13,970
isotope even animal but if and this is

95
00:06:20,590 --> 00:06:17,720
using form of soulful and remaining so2

96
00:06:25,750 --> 00:06:20,600
further oxidized in the sulfate they're

97
00:06:30,280 --> 00:06:25,760
very oxidizing form on sofa and the 33

98
00:06:32,860 --> 00:06:30,290
pitch compound deposited with the

99
00:06:35,200 --> 00:06:32,870
positive anomaly and the oxidizing

100
00:06:39,070 --> 00:06:35,210
species acquires negative anomaly so

101
00:06:39,480 --> 00:06:39,080
this happen under the reducing album

102
00:06:45,870 --> 00:06:39,490
fear

103
00:06:49,140 --> 00:06:45,880
but once the atmosphere is oxidizing no

104
00:06:51,809 --> 00:06:49,150
deducing species are formed that's all

105
00:06:57,510 --> 00:06:51,819
the sulfur entering into the atmosphere

106
00:07:01,559 --> 00:06:57,520
is totally oxidized into survey and it's

107
00:07:07,529 --> 00:07:01,569
positive so that's why after the lives

108
00:07:10,050 --> 00:07:07,539
of oxygen this so for isotopic anomaly

109
00:07:14,550 --> 00:07:10,060
disappeared from the sedimentary rock

110
00:07:18,270 --> 00:07:14,560
record and modeling studies show that

111
00:07:20,999 --> 00:07:18,280
the to preserve this isotopic anomaly

112
00:07:26,730 --> 00:07:21,009
the atmospheric oxygen level should be

113
00:07:29,430 --> 00:07:26,740

less than 1 ppm ok this is the basics so

114
00:07:34,409 --> 00:07:29,440
that's why the presence of this anomaly

115
00:07:38,100 --> 00:07:34,419
means the very very deducing anoxic

116
00:07:45,770 --> 00:07:38,110
conditions but we don't know yet the

117
00:07:54,320 --> 00:07:49,080
in this ten years or many people

118
00:07:58,709 --> 00:07:54,330
including our groups or study which

119
00:08:01,550 --> 00:07:58,719
process as most important for

120
00:08:05,610 --> 00:08:01,560
controlling the isotopic ratio of the

121
00:08:08,850 --> 00:08:05,620
errors of species which are deposited

122
00:08:12,860 --> 00:08:08,860
and finally preserved in the sedimentary

123
00:08:17,629 --> 00:08:12,870
rock record so in the laboratory we

124
00:08:20,580 --> 00:08:17,639
study the each step of the action and

125
00:08:27,300 --> 00:08:20,590
determine the oxygenation factors of

126
00:08:30,149 --> 00:08:27,310
four stable isotopes and so this is like

127
00:08:33,420 --> 00:08:30,159
the shape of elephant is like this is

128
00:08:37,440 --> 00:08:33,430
very complex not that this is a very

129
00:08:40,260 --> 00:08:37,450
simplified view but in reality the other

130
00:08:46,139 --> 00:08:40,270
one chemistry is very complex but in

131
00:08:49,170 --> 00:08:46,149
short that the key step is only 21 is

132
00:08:50,250 --> 00:08:49,180
the photodissociation of so2 and the

133
00:08:53,639 --> 00:08:50,260
other one is the photo excitation

134
00:08:58,410 --> 00:08:53,649
process of again sot

135
00:09:01,750 --> 00:08:58,420
so we use the experimental deep

136
00:09:05,050 --> 00:09:01,760
determined fractionation factor and put

137
00:09:09,760 --> 00:09:05,060
into the chemical reaction Network model

138
00:09:14,949 --> 00:09:09,770

and predict the isotopic are normally

139
00:09:18,310 --> 00:09:14,959
preserved in the sediment as a function

140
00:09:22,780 --> 00:09:18,320
of the chemistry of the atmosphere yeah

141
00:09:27,940 --> 00:09:22,790
and we change the surrounding chemistry

142
00:09:32,139 --> 00:09:27,950
of the atmosphere and this this pathways

143
00:09:35,199 --> 00:09:32,149
changes due to the different chemical

144
00:09:40,600 --> 00:09:35,209
composition of atmosphere and when we

145
00:09:47,110 --> 00:09:40,610
change the D co2 level and the

146
00:09:50,530 --> 00:09:47,120
calculator so this is the isotope degree

147
00:09:56,199 --> 00:09:50,540
of the isotopic anomaly and we found

148
00:10:00,670 --> 00:09:56,209
that even without no excision hyep co2

149
00:10:05,680 --> 00:10:00,680
level is not preferable to preserve the

150
00:10:09,430 --> 00:10:05,690
isotopic anomaly again even without okie

151
00:10:12,519 --> 00:10:09,440
molecular oxygen the too much co2 is

152
00:10:17,829 --> 00:10:12,529
very very oxidizing so the co2 pure co2

153
00:10:21,880 --> 00:10:17,839
atmosphere is oxidizing atmosphere so

154
00:10:26,590 --> 00:10:21,890
not only po2 river but also the PCO

155
00:10:32,670 --> 00:10:26,600
today we can constrain by this isotropic

156
00:10:38,640 --> 00:10:32,680
anomaly study so this estimate level is

157
00:10:44,890 --> 00:10:38,650
less some point Wamba this is lower than

158
00:10:48,250 --> 00:10:44,900
the the pco2 co2 level solving the faint

159
00:10:52,630 --> 00:10:48,260
young Sun Robin this figure is already

160
00:10:57,190 --> 00:10:52,640
shown by our where long rock and the

161
00:11:01,540 --> 00:10:57,200
first they should be simple and I don't

162
00:11:06,069 --> 00:11:01,550
add much thanks but this ill man shows

163
00:11:06,580 --> 00:11:06,079

the stability region liquid water on the

164
00:11:08,710 --> 00:11:06,590
surface

165
00:11:11,860 --> 00:11:08,720
yes and this one's to the increase of

166
00:11:15,040 --> 00:11:11,870
the solar luminosity so the lower bound

167
00:11:21,520 --> 00:11:15,050
means the freeze of the order and this

168
00:11:25,090 --> 00:11:21,530
is vaporized threshold so 0 less than

169
00:11:29,670 --> 00:11:25,100
0.1 but our estimate is the this is the

170
00:11:33,970 --> 00:11:29,680
maximum but the other lines of evidence

171
00:11:37,960 --> 00:11:33,980
mainly from the absence of the iron

172
00:11:42,420 --> 00:11:37,970
carbonate minerals from different ages

173
00:11:48,360 --> 00:11:42,430
of wrestling profile means much lower s

174
00:11:53,760 --> 00:11:48,370
predictive estimated more lower pco2 day

175
00:11:59,890 --> 00:11:53,770
so it's consistent with several other

176
00:12:03,790 --> 00:11:59,900
independent studies and this said that

177
00:12:06,760 --> 00:12:03,800
the the theater is not enough to keep

178
00:12:09,340 --> 00:12:06,770
the Earth's warm enough to solving the

179
00:12:16,330 --> 00:12:09,350
frame and some problem so that's why we

180
00:12:19,210 --> 00:12:16,340
need the more greenhouse gases and trace

181
00:12:24,400 --> 00:12:19,220
gases like methane or ammonium or

182
00:12:26,770 --> 00:12:24,410
somewhere else may be added not only co2

183
00:12:31,210 --> 00:12:26,780
but also the other choice greenhouse

184
00:12:34,270 --> 00:12:31,220
gases may be responsible will keep the

185
00:12:41,560 --> 00:12:34,280
Earth's warm enough to stabilize the

186
00:12:47,980 --> 00:12:41,570
water liquid water so the next thing is

187
00:12:52,240 --> 00:12:47,990
from the other isotopic anomaly and we

188
00:12:55,900 --> 00:12:52,250

can see lots more about the atmosphere

189
00:13:01,900 --> 00:12:55,910
chemistry if we look at another isotope

190
00:13:05,020 --> 00:13:01,910
economy 4036 s this is the most less

191
00:13:08,350 --> 00:13:05,030
less abundant dis abundant species among

192
00:13:12,580 --> 00:13:08,360
the four species and this x-axis shows

193
00:13:15,000 --> 00:13:12,590
the isotopic an oval 33s and y axis

194
00:13:18,220 --> 00:13:15,010
shows the isotope economy for

195
00:13:19,830 --> 00:13:18,230
self-service success and that rihanna is

196
00:13:22,130 --> 00:13:19,840
a mutually correlated

197
00:13:26,870 --> 00:13:22,140
and this red dots are all the

198
00:13:33,510 --> 00:13:26,880
sedimentary aki and geologic record and

199
00:13:35,520 --> 00:13:33,520
this the shape must be produced by the

200
00:13:37,830 --> 00:13:35,530
primary photochemical reaction because

201
00:13:43,470 --> 00:13:37,840
the normally evening the action is very

202
00:13:48,510 --> 00:13:43,480
very exceptional but if you look at

203
00:13:51,300 --> 00:13:48,520
carefully this magnitude and the slope

204
00:13:55,310 --> 00:13:51,310
or laser between the two animals I

205
00:13:59,190 --> 00:13:55,320
changed through time so that could be

206
00:14:03,240 --> 00:13:59,200
some signal from the deepest atmosphere

207
00:14:06,330 --> 00:14:03,250
but we cannot did why this magnitude and

208
00:14:11,600 --> 00:14:06,340
the slope and change through time so

209
00:14:20,460 --> 00:14:15,800
previous researchers are fertilized so2

210
00:14:24,840 --> 00:14:20,470
in the laboratory and making aissatou

211
00:14:29,010 --> 00:14:24,850
succeeded to produce the ball isotopic

212
00:14:32,580 --> 00:14:29,020
anomaly both sulphur 33 and 36 s0 is a

213
00:14:35,880 --> 00:14:32,590

no on money so the result is very

214
00:14:39,630 --> 00:14:35,890
successful to produce very very

215
00:14:44,550 --> 00:14:39,640
exceptional isotope economy but the

216
00:14:47,490 --> 00:14:44,560
problem is that no this data point it's

217
00:14:51,240 --> 00:14:47,500
consistent with the geological record so

218
00:14:54,360 --> 00:14:51,250
if this trend is produced by the mixing

219
00:14:57,780 --> 00:14:54,370
between the software derived from Adams

220
00:15:02,210 --> 00:14:57,790
fear and the other surfers in magnetic

221
00:15:05,160 --> 00:15:02,220
or biological was not derived from

222
00:15:09,260 --> 00:15:05,170
atmosphere is little always little so

223
00:15:12,480 --> 00:15:09,270
the the atmospheric component should be

224
00:15:17,730 --> 00:15:12,490
somewhere around here but no data point

225
00:15:22,520 --> 00:15:17,740
is on this right okay that's a big

226
00:15:27,260 --> 00:15:22,530
problem so why this experiment cannot

227
00:15:31,320 --> 00:15:27,270
diplo this geological you observed trend

228
00:15:33,430 --> 00:15:31,330
that we think the two key reasons one is

229
00:15:39,690 --> 00:15:33,440
the partial pressure s

230
00:15:43,330 --> 00:15:39,700
to the previous experiment is too high

231
00:15:45,610 --> 00:15:43,340
compared to the real world and another

232
00:15:49,240 --> 00:15:45,620
thing important thing is the lead of

233
00:15:52,540 --> 00:15:49,250
state and the purest so2 is very very

234
00:15:57,850 --> 00:15:52,550
oxidizing condition and authorities of

235
00:16:02,650 --> 00:15:57,860
so2 is always produce excess oxygen so

236
00:16:05,410 --> 00:16:02,660
the pure so2 and the presence of so2

237
00:16:07,900 --> 00:16:05,420
itself create a very very very oxidizing

238
00:16:10,360 --> 00:16:07,910

condition that is far different from the

239
00:16:13,480 --> 00:16:10,370
presumed reducing atmosphere of the

240
00:16:15,460 --> 00:16:13,490
arcane period so that's like to scavenge

241
00:16:20,470 --> 00:16:15,470
the excess oxygen we put the carbon

242
00:16:24,100 --> 00:16:20,480
monoxide in the chamber and do the same

243
00:16:29,890 --> 00:16:24,110
sort of experiment by using solar like

244
00:16:33,760 --> 00:16:29,900
ruv source and also we deduce the

245
00:16:36,550 --> 00:16:33,770
partial pressure so2 this is southern

246
00:16:39,840 --> 00:16:36,560
pasco 100 proscar temper scale and one

247
00:16:44,470 --> 00:16:39,850
Pasco and then we can see this trend and

248
00:16:49,330 --> 00:16:44,480
some data point are okay we can

249
00:16:52,890 --> 00:16:49,340
reproduce the geological trend this is

250
00:16:58,120 --> 00:16:52,900
because the presence of so2 itself

251
00:17:01,480 --> 00:16:58,130
change the spectrum of the UV within the

252
00:17:03,640 --> 00:17:01,490
chamber so that recall the self

253
00:17:06,059 --> 00:17:03,650
shielding effect so the different

254
00:17:10,660 --> 00:17:06,069
wavelengths region called the different

255
00:17:13,480 --> 00:17:10,670
topics fractionation so the changing the

256
00:17:18,309 --> 00:17:13,490
UV spectrum by the presence of so2

257
00:17:24,329 --> 00:17:18,319
itself is very very significant a to

258
00:17:29,440 --> 00:17:24,339
significant so this chrome shows the

259
00:17:31,990 --> 00:17:29,450
isotopic relationship 34 33 and 36 as a

260
00:17:36,810 --> 00:17:32,000
function of the total so2 column

261
00:17:40,120 --> 00:17:36,820
densities in a log scale in the previous

262
00:17:42,730 --> 00:17:40,130
experiment too high the compared to the

263
00:17:48,660 --> 00:17:42,740

modern level you know

264
00:17:54,490 --> 00:17:48,670
so even after the huge intense volcanic

265
00:17:59,380 --> 00:17:54,500
eruption like Mount Pinatubo or injector

266
00:18:04,810 --> 00:17:59,390
miyajima item is that a gigantic DD sub

267
00:18:07,240 --> 00:18:04,820
SOT is happening 1981 but still only 20

268
00:18:11,890 --> 00:18:07,250
love mounted higher than the Nova modern

269
00:18:16,390 --> 00:18:11,900
devil okay so in the actual realistic

270
00:18:21,610 --> 00:18:16,400
Ranger of the ps2 we can see the

271
00:18:25,450 --> 00:18:21,620
reasonable the injured the producers

272
00:18:28,810 --> 00:18:25,460
range of the isotope economy and in

273
00:18:32,140 --> 00:18:28,820
other words the partial pressure of so2

274
00:18:36,280 --> 00:18:32,150
can change the magnitude of the isotope

275
00:18:42,130 --> 00:18:36,290
economy so it this isotropic a memory

276
00:18:49,230 --> 00:18:42,140
can be used to monitor the pco2 PSO 20

277
00:18:55,990 --> 00:18:49,240
so or can be used to monitor the

278
00:19:00,490 --> 00:18:56,000
volcanic activity so but the problem is

279
00:19:08,040 --> 00:19:00,500
not solved yet completely because this

280
00:19:11,130 --> 00:19:08,050
slope is not like this so something

281
00:19:16,090 --> 00:19:11,140
additional fractionation is overlapped

282
00:19:21,340 --> 00:19:16,100
so we argue that this trend this yellow

283
00:19:26,160 --> 00:19:21,350
data is by using the solar like UV

284
00:19:31,270 --> 00:19:26,170
spectrum in fact we use the genome ramp

285
00:19:34,560 --> 00:19:31,280
but this is the spectrum of the genogram

286
00:19:38,799 --> 00:19:34,570
that is similar to the solar UV flux

287
00:19:43,500 --> 00:19:38,809
spectrum but if we change the spectrum

288
00:19:47,380 --> 00:19:43,510

like this and this trend is shifted so

289
00:19:50,290 --> 00:19:47,390
we can see some additional things that's

290
00:19:55,520 --> 00:19:50,300
happening the difference between the two

291
00:20:06,420 --> 00:20:03,630
the wavelength regions and so2 is not

292
00:20:10,560 --> 00:20:06,430
only followed Associated bottles of

293
00:20:17,010 --> 00:20:10,570
photoexcited and longer wavelength

294
00:20:19,710 --> 00:20:17,020
visions from about 250 nanometers so

295
00:20:23,480 --> 00:20:19,720
different process can make different

296
00:20:30,930 --> 00:20:23,490
isotopic fractionation and the solar UV

297
00:20:34,080 --> 00:20:30,940
can proceed both photo photo leases or

298
00:20:38,610 --> 00:20:34,090
photodissociation and for excitation and

299
00:20:43,770 --> 00:20:38,620
both but if we use this one only

300
00:20:47,370 --> 00:20:43,780
photoresist oh god to test to this

301
00:20:50,160 --> 00:20:47,380
scenario we cut this wavelength region

302
00:20:53,940 --> 00:20:50,170
by using the optical filter filter and

303
00:20:59,640 --> 00:20:53,950
test the photo excitation effect and yes

304
00:21:03,780 --> 00:20:59,650
we can see the huge isotopic anomalies

305
00:21:06,510 --> 00:21:03,790
and this is for different from a

306
00:21:11,180 --> 00:21:06,520
geological adoption trend but photo

307
00:21:15,690 --> 00:21:11,190
excitation process produce the this

308
00:21:20,550 --> 00:21:15,700
vector of the isotopic fractionation so

309
00:21:23,460 --> 00:21:20,560
we should think about the the mixing of

310
00:21:28,340 --> 00:21:23,470
two processes one is for dissociation

311
00:21:31,890 --> 00:21:28,350
and one is for excitation and create

312
00:21:37,730 --> 00:21:31,900
different manner of voices of extraction

313
00:21:42,840 --> 00:21:37,740

ations but the kissing is a lyric stage

314
00:21:47,160 --> 00:21:42,850
or the amount of the reducing gas in the

315
00:21:52,050 --> 00:21:47,170
atmosphere ok so2 is fertilized into a

316
00:21:55,410 --> 00:21:52,060
soul and some so2 is for excited and the

317
00:22:00,780 --> 00:21:55,420
longer wavelength regions but this

318
00:22:05,820 --> 00:22:00,790
excited states of so2 has a topic

319
00:22:07,170 --> 00:22:05,830
anomaly but easily quenched talk into

320
00:22:11,130 --> 00:22:07,180
ground state of

321
00:22:13,700 --> 00:22:11,140
so too so this isotope economy is not

322
00:22:18,150 --> 00:22:13,710
transferred into the final product

323
00:22:21,720 --> 00:22:18,160
usually but if the atmosphere containing

324
00:22:28,050 --> 00:22:21,730
reducing gas species in our experiment

325
00:22:32,060 --> 00:22:28,060
that is co but in fact the reducing

326
00:22:36,480 --> 00:22:32,070
agent remove the one oxygen from the

327
00:22:41,690 --> 00:22:36,490
exorcist of so2 and transferring s oh

328
00:22:45,180 --> 00:22:41,700
and mix together and this to signal or

329
00:22:47,520 --> 00:22:45,190
mix and transport into the final

330
00:22:54,780 --> 00:22:47,530
preserving the settlement so that's why

331
00:22:59,490 --> 00:22:54,790
the slope of these two isotopic

332
00:23:01,980 --> 00:22:59,500
anomalies can change by the amount of

333
00:23:06,750 --> 00:23:01,990
reducing gases if the autumn of stairs

334
00:23:09,900 --> 00:23:06,760
reducing and this slope is shallow but

335
00:23:12,720 --> 00:23:09,910
its atmosphere is oxidizing and this

336
00:23:15,840 --> 00:23:12,730
slope is steep and the magnitude is

337
00:23:22,680 --> 00:23:15,850
controlled by the pco2 label that it may

338
00:23:28,470 --> 00:23:22,690

be related to the volcanic activity so

339
00:23:31,020 --> 00:23:28,480
now we have a model and we used this

340
00:23:34,400 --> 00:23:31,030
experimental data and model t how the

341
00:23:39,960 --> 00:23:34,410
product and the remaining associations

342
00:23:42,240 --> 00:23:39,970
in this diagram as a function of so2

343
00:23:47,520 --> 00:23:42,250
partial pressure and co partial pressure

344
00:23:52,800 --> 00:23:47,530
and we conclude that about one percent

345
00:23:54,840 --> 00:23:52,810
of the carbon monoxide is present in the

346
00:24:00,750 --> 00:23:54,850
atmosphere we can be produced this group

347
00:24:05,040 --> 00:24:00,760
or methane hydrogen also in the

348
00:24:09,780 --> 00:24:05,050
candidate so as I mentioned earlier the

349
00:24:14,820 --> 00:24:09,790
TM Aaron sir is not a pure co2 of course

350
00:24:18,450 --> 00:24:14,830
and moral reducing than previous results

351
00:24:20,320 --> 00:24:18,460
and possibly including one person amount

352
00:24:26,560 --> 00:24:20,330
of CO or methane

353
00:24:29,799 --> 00:24:26,570
or hydrogen ok so the question is this

354
00:24:36,639 --> 00:24:29,809
sort of high CO out of ashtrays possible

355
00:24:40,149 --> 00:24:36,649
or not sure answer is yes and because

356
00:24:43,180 --> 00:24:40,159
the co2 is always photo eyes in to see

357
00:24:46,210 --> 00:24:43,190
you and oxygen but that Buckley action

358
00:24:50,159 --> 00:24:46,220
CU plus 0 into co2 this is spin forward

359
00:24:54,909 --> 00:24:50,169
reaction so very very very slow the only

360
00:24:58,180 --> 00:24:54,919
think reaction of co is the reaction

361
00:25:00,759 --> 00:24:58,190
between OS radical a hydroxyl radical

362
00:25:05,529 --> 00:25:00,769
that it is formed by the photoresist

363
00:25:08,289 --> 00:25:05,539

water so that's why at least a upper

364
00:25:11,740 --> 00:25:08,299
part of the atmosphere here to adam see

365
00:25:16,659 --> 00:25:11,750
the column on auction is in labor is

366
00:25:19,889 --> 00:25:16,669
increasing and but if the atmosphere

367
00:25:23,399 --> 00:25:19,899
contain or the system contained in a

368
00:25:26,590 --> 00:25:23,409
sufficient amount of the reducing agent

369
00:25:30,490 --> 00:25:26,600
CEO can be sometimes accumulated in the

370
00:25:34,899 --> 00:25:30,500
ionosphere and this one-dimensional

371
00:25:37,810 --> 00:25:34,909
model should if the hydrogen molecular

372
00:25:44,049 --> 00:25:37,820
hydrogen level is high our CEO level

373
00:25:46,750 --> 00:25:44,059
might can be exceeded against the co so

374
00:25:50,889 --> 00:25:46,760
the key question is where the reducing

375
00:25:54,879 --> 00:25:50,899
agent came from the hydrogen or i think

376
00:26:00,669 --> 00:25:54,889
the most likely abundant reducing agent

377
00:26:02,919 --> 00:26:00,679
is iron two-plus ferrous ion is always

378
00:26:07,690 --> 00:26:02,929
supplied by the harder so Monica Vitti

379
00:26:10,360 --> 00:26:07,700
and the event so i am not talk about the

380
00:26:14,379 --> 00:26:10,370
process between our ocean ocean and bent

381
00:26:18,730 --> 00:26:14,389
but in terms of the budget you know the

382
00:26:21,810 --> 00:26:18,740
eye on fox is large enough to scavenging

383
00:26:29,049 --> 00:26:21,820
this oh h that is oxidizing fear into

384
00:26:34,049 --> 00:26:29,059
co2 so as a result if the ion is not

385
00:26:39,730 --> 00:26:37,810
iron oxide is precipitating in fact you

386
00:26:44,680 --> 00:26:39,740
can see a lot of fun in iron formation

387
00:26:46,600 --> 00:26:44,690
in the arcane period so now let's go

388
00:26:48,759 --> 00:26:46,610

back to this slide we can monitor

389
00:26:55,960 --> 00:26:48,769
reducing gas MO and the volcanic

390
00:26:59,590 --> 00:26:55,970
activity should is two things of the

391
00:27:03,340 --> 00:26:59,600
isotopic anomaly and if our molar is

392
00:27:07,870 --> 00:27:03,350
collect the body asian or magnitude of

393
00:27:10,960 --> 00:27:07,880
this scatter means the volcanic activity

394
00:27:13,960 --> 00:27:10,970
the large valuation means the higher

395
00:27:17,830 --> 00:27:13,970
volcanic activity smaller a variation in

396
00:27:20,080 --> 00:27:17,840
the global connect activity and if we

397
00:27:22,990 --> 00:27:20,090
look at the slow pitch in the true

398
00:27:25,509 --> 00:27:23,000
anomaly the shallow slope means the

399
00:27:29,529 --> 00:27:25,519
reducing condition and the steep slope

400
00:27:33,519 --> 00:27:29,539
means oxidizing condition so we can at

401
00:27:35,860 --> 00:27:33,529
least say polite the archaean period

402
00:27:39,870 --> 00:27:35,870
behold great oxidation event at least in

403
00:27:43,330 --> 00:27:39,880
23 pot and other one sir can be

404
00:27:51,600 --> 00:27:43,340
fluctuated reducing oxygen reducing rate

405
00:27:53,740 --> 00:27:51,610
this ok and ok and this to time period

406
00:27:57,159 --> 00:27:53,750
correspond to the higher volcanic

407
00:28:00,120 --> 00:27:57,169
activity at that time at the same time

408
00:28:03,840 --> 00:28:00,130
they are the most serious reducing and

409
00:28:07,090 --> 00:28:03,850
this is consistent with the previous

410
00:28:10,779 --> 00:28:07,100
geological liquid this is a figure show

411
00:28:14,159 --> 00:28:10,789
the college age distribution of the body

412
00:28:17,590 --> 00:28:14,169
ryan formation that make implies the

413
00:28:22,149 --> 00:28:17,600

higher harder form of rocks of iron into

414
00:28:25,029 --> 00:28:22,159
the ocean yes as abundant as in the days

415
00:28:27,399 --> 00:28:25,039
and the problem and also the oxide ball

416
00:28:30,850 --> 00:28:27,409
carriers that are the age population

417
00:28:33,490 --> 00:28:30,860
planet is still strong so the late

418
00:28:35,950 --> 00:28:33,500
archaean period after two point seven

419
00:28:38,649 --> 00:28:35,960
five billion years ago as a higher

420
00:28:41,260 --> 00:28:38,659
brokerage account activity and also how

421
00:28:43,830 --> 00:28:41,270
to some activity and providing a

422
00:28:48,609 --> 00:28:43,840
reducing agent and auto most return

423
00:28:54,009 --> 00:28:48,619
reducing so back to this slide I like to

424
00:28:55,570 --> 00:28:54,019
say so the water lock reaction threw

425
00:28:58,479 --> 00:28:55,580
harder some of the action is very very

426
00:29:03,249 --> 00:28:58,489
very important not only for ocean but

427
00:29:06,759 --> 00:29:03,259
also atmosphere so I'd like to say you

428
00:29:10,509 --> 00:29:06,769
know this figures the misleading to

429
00:29:13,989 --> 00:29:10,519
consider the how the chemistry

430
00:29:18,629 --> 00:29:13,999
automotion all done can change you know

431
00:29:22,269 --> 00:29:18,639
the indiana t we have to see like this

432
00:29:24,639 --> 00:29:22,279
you know else is the low key planet so

433
00:29:27,810 --> 00:29:24,649
the ocean bottom is already 0.02 per

434
00:29:30,339 --> 00:29:27,820
cell it's easily buffered by rock

435
00:29:33,310 --> 00:29:30,349
through the water log reaction that is

436
00:29:36,669 --> 00:29:33,320
weathering her summer reaction and also

437
00:29:40,269 --> 00:29:36,679
both albums face only 0.0004 percents

438
00:29:45,219 --> 00:29:40,279

okay to me it's easy to change by the

439
00:29:46,869 --> 00:29:45,229
reaction between the war the locks so we

440
00:29:51,070 --> 00:29:46,879
have to consider about the link between

441
00:29:53,710 --> 00:29:51,080
Jesus for an atmosphere emotion and also

442
00:29:58,810 --> 00:29:53,720
this might be linked with the climate

443
00:30:02,639 --> 00:29:58,820
and this period is we can I didn't

444
00:30:05,830 --> 00:30:02,649
expand this blue lines the potential

445
00:30:08,019 --> 00:30:05,840
glaciation event this is pongola this is

446
00:30:13,989 --> 00:30:08,029
both Solana this is from southern India

447
00:30:17,409 --> 00:30:13,999
we found addition tree and okay future

448
00:30:20,409 --> 00:30:17,419
is not the major component to counter

449
00:30:23,379 --> 00:30:20,419
the climber over temperature and the

450
00:30:27,489 --> 00:30:23,389
other videos in gases is important you

451
00:30:30,039 --> 00:30:27,499
know the co2 capture the window region

452
00:30:34,210 --> 00:30:30,049
of the ir emission that escaped into

453
00:30:38,070 --> 00:30:34,220
space but equal amount of energy can

454
00:30:41,109 --> 00:30:38,080
absorb the only 1 ppm of the methane or

455
00:30:43,330 --> 00:30:41,119
the other guests psychosis can be

456
00:30:45,759 --> 00:30:43,340
produced is under the cereal each animal

457
00:30:48,070 --> 00:30:45,769
field so we have to think about more

458
00:30:52,239 --> 00:30:48,080
tourists gasp but trace gas is not

459
00:30:54,140 --> 00:30:52,249
trivial to consider the temperature of

460
00:31:07,100 --> 00:30:54,150
the

461
00:31:19,820 --> 00:31:10,260
so we are happy to accept your questions

462
00:31:22,980 --> 00:31:19,830
or comments yeah the 2.7 the increased

463
00:31:26,310 --> 00:31:22,990

volcanism is that could you interpret it

464
00:31:28,560 --> 00:31:26,320
as increased so2 volcanism and not just

465
00:31:29,880 --> 00:31:28,570
I mean could be the change in the gases

466
00:31:33,270 --> 00:31:29,890
that volcanoes are putting up rather

467
00:31:37,760 --> 00:31:33,280
than a Vulcan AMA tree in general that's

468
00:31:44,670 --> 00:31:37,770
yeah that's very interesting why but i

469
00:31:48,470 --> 00:31:44,680
think the yeah oxide volcanism the

470
00:31:53,460 --> 00:31:48,480
several area of volcanism tend to and

471
00:31:56,450 --> 00:31:53,470
how much more effort to compare to h2s

472
00:32:02,930 --> 00:31:56,460
because the pressure the lower pressure

473
00:32:06,030 --> 00:32:02,940
the so2 leader is compared to non so2

474
00:32:11,490 --> 00:32:06,040
h2s ratio of the volcanic gas is

475
00:32:15,570 --> 00:32:11,500
increased on the roof yes low pressure

476
00:32:19,680 --> 00:32:15,580
so sub area of all kinds like island of

477
00:32:22,890 --> 00:32:19,690
volcanism it's responsible for that so

478
00:32:25,950 --> 00:32:22,900
yeah if we look at the you know the

479
00:32:28,230 --> 00:32:25,960
seafloor volcanism we can see different

480
00:32:39,279 --> 00:32:28,240
pictures so that's interesting point I

481
00:32:43,729 --> 00:32:41,299
just a question again about the

482
00:32:45,320 --> 00:32:43,739
volcanism is there a reason you chose

483
00:32:48,590 --> 00:32:45,330
not to think about large igneous

484
00:32:51,499 --> 00:32:48,600
province volcanism to those fissures

485
00:32:52,580 --> 00:32:51,509
back then at least if you predict how

486
00:32:55,399 --> 00:32:52,590
high they go they put a lot of

487
00:33:00,769 --> 00:32:55,409
stratospheric so2 into the exosphere

488
00:33:05,419 --> 00:33:00,779

would be yeah but we don't know much

489
00:33:08,479 --> 00:33:05,429
about that so you know och workers emit

490
00:33:13,700 --> 00:33:08,489
more much more institute compared to non

491
00:33:17,090 --> 00:33:13,710
special type I guess but not canale

492
00:33:23,019 --> 00:33:17,100
lucky right the eyes the example we have

493
00:33:25,820 --> 00:33:23,029
recently lucky lucky option hmm yeah so

494
00:33:29,029 --> 00:33:25,830
yeah large igneous province also

495
00:33:39,190 --> 00:33:29,039
increase at played rock n time but you

496
00:33:45,289 --> 00:33:39,200
know this type of yeah comparison is

497
00:33:48,409 --> 00:33:45,299
still its base so yeah yeah I like to

498
00:33:50,450 --> 00:33:48,419
compare with that you know age

499
00:33:53,269 --> 00:33:50,460
distribution large even in scoring

500
00:34:04,060 --> 00:33:53,279
students but yeah if you have there you

501
00:34:10,970 --> 00:34:07,009
similar question but I'm little confused

502
00:34:14,389 --> 00:34:10,980
at how reduced the volcanic gas because

503
00:34:16,339 --> 00:34:14,399
the this picture is very clear that my

504
00:34:18,349 --> 00:34:16,349
question is how reducible can I guess

505
00:34:20,559 --> 00:34:18,359
and if you don't have a reaction with

506
00:34:24,940 --> 00:34:20,569
the height of some activities and then

507
00:34:29,299 --> 00:34:24,950
could you make you reduce the atmosphere

508
00:34:33,730 --> 00:34:29,309
you know assuming the the mountain

509
00:34:37,129 --> 00:34:33,740
lyrics state that's buffer likely ahem

510
00:34:42,580 --> 00:34:37,139
omaha beach and then the volcanic gets

511
00:34:46,550 --> 00:34:42,590
to be donated by h2 and then co2

512
00:34:51,649 --> 00:34:46,560
but the addition of co2 is not you know

513
00:34:54,200 --> 00:34:51,659

i think is trivial because if the point

514
00:34:58,160 --> 00:34:54,210
one ball field is already available in

515
00:35:03,310 --> 00:34:58,170
the LOC so but the interaction between

516
00:35:06,980 --> 00:35:03,320
you know this is fear and hydrosphere

517
00:35:08,630 --> 00:35:06,990
atmosphere is two types one is director

518
00:35:10,220 --> 00:35:08,640
you know addition of gases by the

519
00:35:13,250 --> 00:35:10,230
volcanic rocks dude this is high

520
00:35:16,490 --> 00:35:13,260
temperature process but as I actually

521
00:35:17,780 --> 00:35:16,500
mention one more lower temperature you

522
00:35:20,270 --> 00:35:17,790
know introduction that is the

523
00:35:25,960 --> 00:35:20,280
hydrothermal you know circulation and

524
00:35:28,400 --> 00:35:25,970
also weatherly of continent or mercy for

525
00:35:34,670 --> 00:35:28,410
that should be taken into account that

526
00:35:37,340 --> 00:35:34,680
is my what I'm trying to say yeah if you

527
00:35:39,890 --> 00:35:37,350
mean at least of even have any ocean

528
00:35:41,930 --> 00:35:39,900
surface water you didn't you couldn't

529
00:35:46,160 --> 00:35:41,940
have any so I hydrofarm activities and

530
00:35:49,730 --> 00:35:46,170
then but you have enough you mean no

531
00:35:51,680 --> 00:35:49,740
order but like Mark like Mars and if you

532
00:35:54,710 --> 00:35:51,690
don't have any water on the surface and

533
00:36:02,480 --> 00:35:54,720
then volcanic activities could not

534
00:36:06,290 --> 00:36:02,490
produce the videos atmosphere right yeah

535
00:36:08,990 --> 00:36:06,300
it's yeah I only said that in terms of

536
00:36:13,520 --> 00:36:09,000
budget but I don't argue that you know

537
00:36:17,870 --> 00:36:13,530
the mechanism so yeah that's it I think

538
00:36:21,590 --> 00:36:17,880

it's in for interfering and our war is a

539
00:36:25,400 --> 00:36:21,600
very good medium to faceted the action I

540
00:36:31,070 --> 00:36:25,410
think so yeah I can't imagine so for

541
00:36:34,600 --> 00:36:31,080
that yeah it's interesting question can

542
00:36:38,030 --> 00:36:34,610
I ask you a naive question so can you

543
00:36:40,340 --> 00:36:38,040
extrapolate some part of Hadean

544
00:36:43,700 --> 00:36:40,350
atomosphere hidden environment from your

545
00:36:56,720 --> 00:36:52,550
mm-hmm just yeah very difficult but yeah

546
00:37:01,070 --> 00:36:56,730
it depends on the model so after how

547
00:37:07,910 --> 00:37:01,080
fast the unit like are very show the

548
00:37:10,780 --> 00:37:07,920
first day and how fast do you know the

549
00:37:15,890 --> 00:37:10,790
CEO to leave is buffered by did you know

550
00:37:18,410 --> 00:37:15,900
the several processes and yeah we can

551
00:37:21,680 --> 00:37:18,420
provide the one you know boundary

552
00:37:26,329 --> 00:37:21,690
conditions so I think it depends on the

553
00:37:29,690 --> 00:37:26,339
model if you know we don't have not much

554
00:37:33,230 --> 00:37:29,700
you know geological samples so your

555
00:37:47,660 --> 00:37:33,240
chemist doesn't say anything dielectric

556
00:37:54,620 --> 00:37:50,960
hey hey you true also possibly naive

557
00:37:56,930 --> 00:37:54,630
question but I was wondering if with the

558
00:37:59,500 --> 00:37:56,940
amount of so2 that you think is going to

559
00:38:02,690 --> 00:37:59,510
the atmosphere if that would connect to

560
00:38:06,020 --> 00:38:02,700
these big sulfate deposits that are

561
00:38:09,230 --> 00:38:06,030
found around 3.4 billion years ago these

562
00:38:14,990 --> 00:38:09,240
berries North Pole barite things yes I

563
00:38:26,829 --> 00:38:15,000

think so for not just some deposit yeah

564
00:38:33,920 --> 00:38:31,280
to produce a large isotopic anna-marie

565
00:38:38,420 --> 00:38:33,930
it needs the very dense or particular

566
00:38:42,500 --> 00:38:38,430
thickness of so2 but the lifetime so2 is

567
00:38:44,960 --> 00:38:42,510
very short as several years not merely

568
00:38:49,460 --> 00:38:44,970
anxious you know so that's why I think

569
00:38:55,940 --> 00:38:49,470
that are normally producing a process a

570
00:38:58,670 --> 00:38:55,950
very short of phenomena like after the

571
00:39:04,940 --> 00:38:58,680
volcanic eruption I hope for example

572
00:39:07,970 --> 00:39:04,950
yeah so several so faith deposit is may

573
00:39:12,170 --> 00:39:07,980
be related to just kind of you know what

574
00:39:16,130 --> 00:39:12,180
can a vent yes likely possibility i

575
00:39:30,270 --> 00:39:16,140
think and their goal should be can be

576
00:39:35,740 --> 00:39:33,880
yeah you have a picture of banded I

577
00:39:37,410 --> 00:39:35,750
information you have the letter e on top

578
00:39:39,550 --> 00:39:37,420
of it you say equals reducing atmosphere

579
00:39:41,440 --> 00:39:39,560
during when there is a reducing

580
00:39:43,120 --> 00:39:41,450
atmosphere what is it that the varying

581
00:39:44,680 --> 00:39:43,130
that's producing the stripes in the

582
00:39:47,220 --> 00:39:44,690
banded iron formation is it's of aqueous

583
00:39:50,340 --> 00:39:47,230
volcanism or something or what is it

584
00:39:54,850 --> 00:39:50,350
yeah that's a huge argument there is

585
00:40:00,850 --> 00:39:54,860
here you have a new one yeah it could be

586
00:40:04,810 --> 00:40:00,860
you know the part of the you know the

587
00:40:08,890 --> 00:40:04,820
periodic emission of the event that can

588
00:40:11,170 --> 00:40:08,900

create Bob like structure so that is one

589
00:40:14,470 --> 00:40:11,180
possibility okay intermittent emission

590
00:40:16,480 --> 00:40:14,480
of fe 2 from hydrothermal vent that is

591
00:40:21,220 --> 00:40:16,490
one possibility okay and then somebody

592
00:40:26,650 --> 00:40:21,230
says this is in annual you know like on

593
00:40:28,570 --> 00:40:26,660
a daily or year recycle but it's still

594
00:40:31,690 --> 00:40:28,580
controversial but it's possible to

595
00:40:34,480 --> 00:40:31,700
deflect in a periodic input a higher

596
00:40:37,420 --> 00:40:34,490
cement result and the other the other

597
00:40:40,740 --> 00:40:37,430
people who disagree with that say yeah

598
00:40:49,850 --> 00:40:40,750
they're long long you know debate yeah

599
00:40:58,160 --> 00:40:51,980
I'm sorry still have five more minutes

600
00:40:59,360 --> 00:40:58,170
what I have a question if possible hi I

601
00:41:01,820 --> 00:40:59,370
very much enjoyed your presentation

602
00:41:03,530 --> 00:41:01,830
thank you and thank you with some

603
00:41:05,330 --> 00:41:03,540
colleagues we would publish some work

604
00:41:07,850 --> 00:41:05,340
that suggests that air pressure at

605
00:41:10,040 --> 00:41:07,860
around 2.9 was less than modern right

606
00:41:12,500 --> 00:41:10,050
now wondering if that would magnify the

607
00:41:13,940 --> 00:41:12,510
effects of a sulfur injection to the

608
00:41:23,590 --> 00:41:13,950
atmosphere and would that be reflected

609
00:41:32,950 --> 00:41:26,300
it's not the magnifier that you know

610
00:41:36,800 --> 00:41:32,960
story is the same yeah but every if co2

611
00:41:39,550 --> 00:41:36,810
levels on one bar with 10 bar that's a

612
00:41:45,760 --> 00:41:39,560
totally different story so because the

613
00:41:48,710 --> 00:41:45,770

co2 is fielding they you know this

614
00:41:51,410 --> 00:41:48,720
wavelength region responsible for the

615
00:41:54,920 --> 00:41:51,420
so2 photoresist and excitation so it's

616
00:42:00,320 --> 00:41:54,930
highly highly relevant if total pressure

617
00:42:03,680 --> 00:42:00,330
be decided by co2 but if you know total

618
00:42:09,530 --> 00:42:03,690
pressure is changed by m2 G nitrogen

619
00:42:16,430 --> 00:42:09,540
that's invisible for me I can't get the

620
00:42:24,500 --> 00:42:16,440
elephant looks good thank you any other

621
00:42:28,250 --> 00:42:24,510
naive question hi Greta just want to ask

622
00:42:34,130 --> 00:42:28,260
you a you commented that the most

623
00:42:36,970 --> 00:42:34,140
important input to early Earth's

624
00:42:43,330 --> 00:42:36,980
atmosphere might have been the input /

625
00:42:48,710 --> 00:42:43,340
Ferris Aaron why do you think that the

626
00:42:50,780 --> 00:42:48,720
outgassing of reducing gases those

627
00:42:57,680 --> 00:42:50,790
fluxes should be smaller than Sarah

628
00:43:04,170 --> 00:43:00,560
that's simply because of the you know

629
00:43:08,910 --> 00:43:04,180
the estimated sucks and you know likely

630
00:43:11,670 --> 00:43:08,920
possibility but compared to reach one

631
00:43:14,130 --> 00:43:11,680
guy they are so you mentioned with a

632
00:43:17,730 --> 00:43:14,140
flat I just hangin on the level is

633
00:43:19,970 --> 00:43:17,740
mole's per year I just converted II know

634
00:43:24,060 --> 00:43:19,980
that is the present-day facts oh no

635
00:43:40,590 --> 00:43:24,070
value to modern Cecil okay as it could

636
00:43:44,710 --> 00:43:40,600
be higher than that yeah okay okay so