



Earth-like Planets with Phosphorus-limited Biosphere: Competition between Continental and Seafloor Weathering

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1
00:00:04,150 --> 00:00:01,990
hi i am sir watanabe from the university

2
00:00:06,389 --> 00:00:04,160
of tokyo i talk about the competition

3
00:00:09,669 --> 00:00:06,399
between concentra and syria with ring on

4
00:00:13,110 --> 00:00:11,669
detecting the extraterrestrial life is

5
00:00:15,430 --> 00:00:13,120
one of the ultimate goal of the

6
00:00:17,510 --> 00:00:15,440
observations of exoplanets

7
00:00:19,349 --> 00:00:17,520
upcoming observations of exoplanetary

8
00:00:21,750 --> 00:00:19,359
atmosphere would allow us to detect

9
00:00:23,670 --> 00:00:21,760
design of life in the future so that the

10
00:00:25,670 --> 00:00:23,680
process controlling the composition of

11
00:00:27,189 --> 00:00:25,680
the planetary atmosphere is now actively

12
00:00:29,189 --> 00:00:27,199
discussed

13
00:00:31,269 --> 00:00:29,199

among the constitute of the primary

14
00:00:33,030 --> 00:00:31,279
atmosphere oxygen has been discussed to

15
00:00:35,590 --> 00:00:33,040
be one of the strong biosignatures if

16
00:00:37,430 --> 00:00:35,600
you detected on x granite

17
00:00:40,549 --> 00:00:37,440
in the present atmosphere of the earth

18
00:00:42,950 --> 00:00:40,559
oxygen compresses 12 percent

19
00:00:45,029 --> 00:00:42,960
because oxygen is produced by oxygenic

20
00:00:46,950 --> 00:00:45,039
photosynthesis high concentration of

21
00:00:49,510 --> 00:00:46,960
oxygen in the exoplanetary atmosphere

22
00:00:51,750 --> 00:00:49,520
may indicate the existence of life

23
00:00:53,990 --> 00:00:51,760
thus how the oxygen level is controlled

24
00:00:57,029 --> 00:00:54,000
in the primary atmosphere is crucial to

25
00:00:58,790 --> 00:00:57,039
interpret the biosignature

26

00:01:01,910 --> 00:00:58,800

for this purpose we focus on the

27

00:01:03,590 --> 00:01:01,920

evolution of the oxygen level on earth

28

00:01:05,990 --> 00:01:03,600

in the history of the earth the

29

00:01:08,230 --> 00:01:06,000

atmospheric oxygen level was not kept as

30

00:01:09,670 --> 00:01:08,240

high as it is today in the early years

31

00:01:11,429 --> 00:01:09,680

the oxygen level was smaller than

32

00:01:13,190 --> 00:01:11,439

represented by more

33

00:01:15,429 --> 00:01:13,200

order of magnitude

34

00:01:17,590 --> 00:01:15,439

from such an anoxic condition

35

00:01:19,830 --> 00:01:17,600

the atmospheric oxygen level abruptly

36

00:01:21,510 --> 00:01:19,840

increased at around 2.3 billion years

37

00:01:23,749 --> 00:01:21,520

ago which is known as the great

38

00:01:26,070 --> 00:01:23,759

oxidation event

39
00:01:28,070 --> 00:01:26,080
various mechanisms has been proposed to

40
00:01:30,390 --> 00:01:28,080
explain degradation of great oxidation

41
00:01:35,030 --> 00:01:30,400
event but here i focus on the mechanism

42
00:01:39,910 --> 00:01:37,830
in the presentation the production rate

43
00:01:42,550 --> 00:01:39,920
of oxygen is limited by the supply of

44
00:01:44,630 --> 00:01:42,560
nutrient on a global perspective the

45
00:01:47,510 --> 00:01:44,640
marine primary productivity is limited

46
00:01:49,830 --> 00:01:47,520
by the rivalry input of phosphorus thus

47
00:01:52,230 --> 00:01:49,840
the atmospheric oxygen level is strongly

48
00:01:55,350 --> 00:01:52,240
linked to the phosphorus cycle on the

49
00:01:57,109 --> 00:01:55,360
planetary surface phosphorus is produced

50
00:01:59,590 --> 00:01:57,119
during the weathering of the carbonate

51
00:02:01,270 --> 00:01:59,600
and silicate mineral on the continent

52
00:02:03,270 --> 00:02:01,280
that grassed and is

53
00:02:06,310 --> 00:02:03,280
removed from the ocean as an organic

54
00:02:08,229 --> 00:02:06,320
carbon or inorganic compounds

55
00:02:10,309 --> 00:02:08,239
weathering of seafloor basalt is not

56
00:02:12,390 --> 00:02:10,319
expected to provide phosphorus because

57
00:02:14,949 --> 00:02:12,400
it precipitates as an appetite in dc

58
00:02:17,110 --> 00:02:14,959
flow so the phosphorus input rate and

59
00:02:19,830 --> 00:02:17,120
the atmospheric oxygen level depends on

60
00:02:22,070 --> 00:02:19,840
the concentration efficiency

61
00:02:23,350 --> 00:02:22,080
so the red shaded area in the right

62
00:02:25,350 --> 00:02:23,360
figure

63
00:02:28,150 --> 00:02:25,360

is the marine primary productivity

64
00:02:30,710 --> 00:02:28,160
estimated based on the phosphorus budget

65
00:02:32,229 --> 00:02:30,720
which is increased during the middle to

66
00:02:34,550 --> 00:02:32,239
let again

67
00:02:36,949 --> 00:02:34,560
this increase is driven by the growth of

68
00:02:40,309 --> 00:02:36,959
the congenital crust which is estimated

69
00:02:42,229 --> 00:02:40,319
to have happened during this period

70
00:02:44,710 --> 00:02:42,239
thus the growth of the congenital crust

71
00:02:46,150 --> 00:02:44,720
would becomes crucial

72
00:02:47,670 --> 00:02:46,160
in controlling the atmospheric

73
00:02:49,830 --> 00:02:47,680
composition through

74
00:02:52,070 --> 00:02:49,840
the biogeochemical processes associated

75
00:02:53,910 --> 00:02:52,080
with the phosphorus cycle

76

00:02:55,670 --> 00:02:53,920

however the consequence of the

77

00:02:57,750 --> 00:02:55,680

congenital growth on the atmospheric

78

00:03:00,869 --> 00:02:57,760

composition has not been systematically

79

00:03:05,030 --> 00:03:03,110

and one of the other important aspect of

80

00:03:07,190 --> 00:03:05,040

the earth red planets is the variation

81

00:03:09,350 --> 00:03:07,200

of orbital parameters

82

00:03:11,750 --> 00:03:09,360

these are the calculated variations of

83

00:03:14,070 --> 00:03:11,760

obliquity and the planetary

84

00:03:15,430 --> 00:03:14,080

orbital eccentricity of the past earth

85

00:03:17,110 --> 00:03:15,440

and mass

86

00:03:19,110 --> 00:03:17,120

it is well known that this kind of

87

00:03:21,670 --> 00:03:19,120

orbital variation have caused the

88

00:03:23,270 --> 00:03:21,680

glacial cyclone quaternary earth even

89

00:03:25,350 --> 00:03:23,280

though the change in the orbital

90

00:03:27,350 --> 00:03:25,360

parameters on earth especially obligated

91

00:03:29,110 --> 00:03:27,360

is small because of the existence of the

92

00:03:31,750 --> 00:03:29,120

moon

93

00:03:33,670 --> 00:03:31,760

in a product context of the exoplanet

94

00:03:36,070 --> 00:03:33,680

the various of orbital parameters could

95

00:03:37,430 --> 00:03:36,080

vary in a wider range of the parameter

96

00:03:39,509 --> 00:03:37,440

space

97

00:03:42,229 --> 00:03:39,519

it has been discussed that the different

98

00:03:43,430 --> 00:03:42,239

values of obligation and eccentricity

99

00:03:46,149 --> 00:03:43,440

could affect the climate and

100

00:03:48,390 --> 00:03:46,159

habitability of earth-like planets

101

00:03:50,229 --> 00:03:48,400

however how the different varies of

102

00:03:53,350 --> 00:03:50,239

orbital parameters could affect the

103

00:03:55,429 --> 00:03:53,360

coupled system of climate biosphere and

104

00:03:57,750 --> 00:03:55,439

atoms has not been systematically

105

00:03:58,869 --> 00:03:57,760

demonstrated

106

00:04:01,030 --> 00:03:58,879

so

107

00:04:02,470 --> 00:04:01,040

our purpose here is to elucidate the

108

00:04:04,789 --> 00:04:02,480

links between the growth of the

109

00:04:07,509 --> 00:04:04,799

continental crust orbital parameters and

110

00:04:09,509 --> 00:04:07,519

the atmospheric composition to discuss

111

00:04:11,350 --> 00:04:09,519

the country and condition to achieve the

112

00:04:13,670 --> 00:04:11,360

high atmospheric oxygen level in the

113

00:04:16,069 --> 00:04:13,680

atmosphere of the earth and earth-like

114

00:04:19,749 --> 00:04:16,079

planets with phosphorus limited marine

115

00:04:23,350 --> 00:04:21,349

for this purpose we employed a

116

00:04:25,590 --> 00:04:23,360

simplified ocean and atmosphere box

117

00:04:28,150 --> 00:04:25,600

model in which a long-time steady state

118

00:04:29,510 --> 00:04:28,160

of phosphorus carbon and oxygen cycle is

119

00:04:31,110 --> 00:04:29,520

calculated

120

00:04:33,030 --> 00:04:31,120

we use the parameterization of

121

00:04:35,670 --> 00:04:33,040

atmospheric photochemistry to calculate

122

00:04:37,510 --> 00:04:35,680

the budget of oxygen in the atmosphere

123

00:04:38,710 --> 00:04:37,520

for the climate model we use the

124

00:04:40,390 --> 00:04:38,720

parameterization based on

125

00:04:42,310 --> 00:04:40,400

one-dimensional radiative convective

126
00:04:44,070 --> 00:04:42,320
models

127
00:04:45,830 --> 00:04:44,080
and we also use the meridian

128
00:04:48,150 --> 00:04:45,840
one-dimensional energy balanced climate

129
00:04:49,749 --> 00:04:48,160
model to illustrate the rows of orbital

130
00:04:52,070 --> 00:04:49,759
parameters

131
00:04:54,070 --> 00:04:52,080
the steady-state co2 level is buffered

132
00:04:55,990 --> 00:04:54,080
by the container and zero weathering

133
00:04:57,909 --> 00:04:56,000
whose relative contribution becomes

134
00:05:00,870 --> 00:04:57,919
crucial on the

135
00:05:04,629 --> 00:05:03,029
so first we show the dependencies of the

136
00:05:07,590 --> 00:05:04,639
concentrated weathering and seafloor

137
00:05:09,590 --> 00:05:07,600
measuring on co2 and temperature which

138
00:05:11,909 --> 00:05:09,600

becomes crucial in controlling the

139

00:05:13,510 --> 00:05:11,919

rivalry phosphorus input rate

140

00:05:15,830 --> 00:05:13,520

in this figure the sensitivity of

141

00:05:18,870 --> 00:05:15,840

continent and separating to the

142

00:05:21,350 --> 00:05:18,880

atmospheric sealed level and temperature

143

00:05:23,909 --> 00:05:21,360

is shown the container weathering has a

144

00:05:25,430 --> 00:05:23,919

stronger co2 dependency while seafloor

145

00:05:29,189 --> 00:05:25,440

weathering has a much stronger

146

00:05:33,590 --> 00:05:31,670

as a result combining these dependencies

147

00:05:35,670 --> 00:05:33,600

sephora weathering rate has a stronger

148

00:05:37,830 --> 00:05:35,680

sensitivity to the climate warming

149

00:05:39,909 --> 00:05:37,840

caused by the change in atmospheric co2

150

00:05:43,590 --> 00:05:39,919

level while the content arrest and grade

151
00:05:45,510 --> 00:05:43,600
also increases with co2 driven warming

152
00:05:47,909 --> 00:05:45,520
as a result the riverline phosphorus

153
00:05:50,230 --> 00:05:47,919
input rate is also increased because

154
00:05:55,430 --> 00:05:50,240
container weathering is enhanced with

155
00:05:59,350 --> 00:05:57,510
because not only is it content that are

156
00:06:01,909 --> 00:05:59,360
weathering but also that seafaring

157
00:06:04,469 --> 00:06:01,919
buffers decline it the phosphorus input

158
00:06:08,309 --> 00:06:04,479
rate depends on the climate change as

159
00:06:11,590 --> 00:06:10,070
so next we should discuss the

160
00:06:12,710 --> 00:06:11,600
sensitivity to the machine driven

161
00:06:14,469 --> 00:06:12,720
warming

162
00:06:16,309 --> 00:06:14,479
in this figure the response of the

163
00:06:19,029 --> 00:06:16,319

phosphorous supply rate to the

164

00:06:21,110 --> 00:06:19,039

atmospheric missing level is summarized

165

00:06:24,710 --> 00:06:21,120

different lines represent the result

166

00:06:26,550 --> 00:06:24,720

with different pseudo outgassing flux

167

00:06:28,950 --> 00:06:26,560

because methane is a strong greenhouse

168

00:06:30,309 --> 00:06:28,960

gas it increases the equilibrium surface

169

00:06:32,070 --> 00:06:30,319

temperature

170

00:06:34,309 --> 00:06:32,080

where it decreases the equilibrium

171

00:06:36,550 --> 00:06:34,319

atmospheric co2 level through a silicate

172

00:06:38,309 --> 00:06:36,560

weathering negative feedback

173

00:06:40,390 --> 00:06:38,319

because lower sealed

174

00:06:41,909 --> 00:06:40,400

atmosphere to level and higher surface

175

00:06:43,830 --> 00:06:41,919

temperature promotes the severe

176

00:06:45,590 --> 00:06:43,840

weathering strongly

177

00:06:47,430 --> 00:06:45,600

the increase in the atmospheric messing

178

00:06:49,430 --> 00:06:47,440

level due to the decrease in the

179

00:06:50,790 --> 00:06:49,440

continental weathering as showing the

180

00:06:53,029 --> 00:06:50,800

solid line

181

00:06:55,350 --> 00:06:53,039

hence the river and phosphorus supply

182

00:06:58,070 --> 00:06:55,360

rate is also decreased

183

00:07:02,070 --> 00:07:00,230

thus the competition between continental

184

00:07:07,670 --> 00:07:02,080

and seafloor weighting could affect the

185

00:07:11,830 --> 00:07:09,270

then what happens

186

00:07:13,909 --> 00:07:11,840

if content area is increased as a result

187

00:07:15,830 --> 00:07:13,919

of the container growth

188

00:07:18,070 --> 00:07:15,840

these are the response of the co2

189

00:07:21,430 --> 00:07:18,080

phosphorous input rate and oxygen level

190

00:07:23,430 --> 00:07:21,440

against the increasing content area

191

00:07:25,670 --> 00:07:23,440

different lines represent a different

192

00:07:28,230 --> 00:07:25,680

co2 addressing rate

193

00:07:31,110 --> 00:07:28,240

as the container area increases steady

194

00:07:32,469 --> 00:07:31,120

state co2 level is decreased

195

00:07:33,589 --> 00:07:32,479

as a result of

196

00:07:36,469 --> 00:07:33,599

increasing

197

00:07:38,950 --> 00:07:36,479

congenital weight and efficiency

198

00:07:41,430 --> 00:07:38,960

the primary productivity in the ocean

199

00:07:43,029 --> 00:07:41,440

increases as a result of an increased

200

00:07:45,029 --> 00:07:43,039

phosphorus input

201
00:07:47,270 --> 00:07:45,039
to the ocean

202
00:07:48,230 --> 00:07:47,280
so now we see the atmospheric oxygen

203
00:07:50,790 --> 00:07:48,240
level

204
00:07:53,350 --> 00:07:50,800
when the content area is very small

205
00:07:55,589 --> 00:07:53,360
there's only an equilibrium

206
00:07:59,589 --> 00:07:55,599
with small atmospheric oxygen level even

207
00:08:02,230 --> 00:07:59,599
with large shield glassing rate

208
00:08:05,909 --> 00:08:04,150
with the present theory guessing rate

209
00:08:08,390 --> 00:08:05,919
shown in blue line the atmospheric

210
00:08:10,469 --> 00:08:08,400
oxygen level slightly increases but it

211
00:08:13,430 --> 00:08:10,479
is still kept low even with the present

212
00:08:15,510 --> 00:08:13,440
content area on the other hand when the

213
00:08:18,309 --> 00:08:15,520

co2 gassing rate is sufficient the

214

00:08:21,270 --> 00:08:18,319

branch of low oxygen level disappears

215

00:08:23,189 --> 00:08:21,280

as the content area increases as the

216

00:08:25,270 --> 00:08:23,199

gradient

217

00:08:27,110 --> 00:08:25,280

and the abrupt rise of oxygen is

218

00:08:29,589 --> 00:08:27,120

triggered

219

00:08:31,510 --> 00:08:29,599

so contented growth can drive the abrupt

220

00:08:36,149 --> 00:08:31,520

increase in the atmospheric oxygen when

221

00:08:41,269 --> 00:08:39,110

next we see the dependency of a model on

222

00:08:44,230 --> 00:08:41,279

orbital parameters

223

00:08:46,630 --> 00:08:44,240

this is a response of the co2 and global

224

00:08:47,990 --> 00:08:46,640

mean temperature

225

00:08:50,389 --> 00:08:48,000

and surface temperature and the

226

00:08:53,190 --> 00:08:50,399

weathering rates to different varieties

227

00:08:55,509 --> 00:08:53,200

of mean eccentricity of a planet

228

00:08:57,190 --> 00:08:55,519

the atmospheric co2 level decreases and

229

00:08:58,389 --> 00:08:57,200

the surface temperature increases

230

00:09:01,030 --> 00:08:58,399

against the

231

00:09:03,430 --> 00:09:01,040

increasing eccentricity

232

00:09:06,550 --> 00:09:03,440

in this case the solar irradiance at low

233

00:09:08,310 --> 00:09:06,560

ratio regions

234

00:09:10,470 --> 00:09:08,320

increases with the increasing

235

00:09:13,030 --> 00:09:10,480

eccentricity so that the global mean

236

00:09:15,030 --> 00:09:13,040

surface temperature also increases

237

00:09:17,269 --> 00:09:15,040

because container weathering is less

238

00:09:19,430 --> 00:09:17,279

effective under low co2 and high

239

00:09:20,790 --> 00:09:19,440

temperature conditions there phosphorus

240

00:09:22,710 --> 00:09:20,800

input and the marine primary

241

00:09:29,350 --> 00:09:22,720

productivity as small

242

00:09:32,790 --> 00:09:31,110

on the other hand this is the response

243

00:09:33,829 --> 00:09:32,800

of the different mean obligation of a

244

00:09:35,990 --> 00:09:33,839

planet

245

00:09:38,389 --> 00:09:36,000

the atmospheric field level is peaked at

246

00:09:40,150 --> 00:09:38,399

around 40 to 50

247

00:09:42,150 --> 00:09:40,160

degrees of obligation so that the

248

00:09:43,430 --> 00:09:42,160

weathering rate is also dependent on

249

00:09:45,590 --> 00:09:43,440

operating

250

00:09:48,550 --> 00:09:45,600

this is associated with the rational

251

00:09:51,269 --> 00:09:48,560

distribution of the insulation forcing

252

00:09:54,550 --> 00:09:51,279

it is uniformly distributed at around

253

00:09:58,630 --> 00:09:54,560

this values of obligation which

254

00:10:00,870 --> 00:09:58,640

resulted in the low global temperature

255

00:10:02,790 --> 00:10:00,880

thus both obligated and eccentricity

256

00:10:04,389 --> 00:10:02,800

could affect the marine biosphere and

257

00:10:06,150 --> 00:10:04,399

atmosphere

258

00:10:10,630 --> 00:10:06,160

through the competition of the

259

00:10:15,750 --> 00:10:13,269

so here we summarize the response of the

260

00:10:17,590 --> 00:10:15,760

co2 primary productivity and the

261

00:10:19,269 --> 00:10:17,600

atmospheric oxygen level to the

262

00:10:21,030 --> 00:10:19,279

different varies of obligation and

263

00:10:23,430 --> 00:10:21,040

eccentricity

264

00:10:26,069 --> 00:10:23,440

as we showed the atmospheric co2 level

265

00:10:27,430 --> 00:10:26,079

and the primary productivity is high

266

00:10:29,990 --> 00:10:27,440

under the condition with low

267

00:10:31,509 --> 00:10:30,000

eccentricity and also dependent on

268

00:10:33,910 --> 00:10:31,519

obliquity

269

00:10:35,829 --> 00:10:33,920

as a result the range

270

00:10:38,389 --> 00:10:35,839

of the condition that can sustain the

271

00:10:41,269 --> 00:10:38,399

high atmospheric oxygen level could vary

272

00:10:43,350 --> 00:10:41,279

as in the case we are showing here

273

00:10:45,509 --> 00:10:43,360

thus orbital parameters are important

274

00:10:47,430 --> 00:10:45,519

not only for climate and habitability

275

00:10:49,350 --> 00:10:47,440

but also the atmosphere and marine

276

00:10:51,190 --> 00:10:49,360

biological chemistry through the

277

00:10:53,990 --> 00:10:51,200

competition between container and

278

00:10:55,990 --> 00:10:54,000

seafloor weathering

279

00:10:58,550 --> 00:10:56,000

so this is the summary of our

280

00:11:00,230 --> 00:10:58,560

presentation the marine biosphere and

281

00:11:02,550 --> 00:11:00,240

atmospheric composition could be

282

00:11:03,750 --> 00:11:02,560

affected by the co2 and missing driven

283

00:11:06,230 --> 00:11:03,760

warmings

284

00:11:06,949 --> 00:11:06,240

and also by contented growth and also by

285

00:11:07,910 --> 00:11:06,959

the

286

00:11:09,030 --> 00:11:07,920

different

287

00:11:11,269 --> 00:11:09,040

values of

288

00:11:13,190 --> 00:11:11,279

orbital parameters through the

289

00:11:14,790 --> 00:11:13,200

competition between congenital and

290

00:11:17,030 --> 00:11:14,800

severe weathering

291

00:11:20,069 --> 00:11:17,040

which is a fundamental process for the