



AbGradCon 2018

1
00:00:00,260 --> 00:00:11,740

[Music]

2
00:00:15,250 --> 00:00:14,060

all right well thank you everyone for

3
00:00:17,300 --> 00:00:15,260

having me

4
00:00:19,820 --> 00:00:17,310

before I begin I just want to very

5
00:00:22,820 --> 00:00:19,830

briefly acknowledge my co-authors so the

6
00:00:24,170 --> 00:00:22,830

first is my PhD advisor Phil shop as

7
00:00:26,390 --> 00:00:24,180

well as our lab member and research

8
00:00:29,050 --> 00:00:26,400

scientist Anatoly could you add Saif who

9
00:00:31,520 --> 00:00:29,060

contributed a great deal to this work

10
00:00:34,010 --> 00:00:31,530

okay so really one of the most

11
00:00:35,959 --> 00:00:34,020

fundamental aspects of our planets

12
00:00:38,300 --> 00:00:35,969

evolution has been the history of

13
00:00:40,040 --> 00:00:38,310

oxygenation of our oceans and

14

00:00:41,900 --> 00:00:40,050

atmospheres and so this is from the

15

00:00:44,180 --> 00:00:41,910

Hadean and our kin which essentially had

16

00:00:45,620 --> 00:00:44,190

no free oxygen available all the way

17

00:00:47,270 --> 00:00:45,630

through our current atmospheric

18

00:00:49,340 --> 00:00:47,280

composition of about 20%

19

00:00:50,780 --> 00:00:49,350

I want to thank Becky this morning for

20

00:00:52,460 --> 00:00:50,790

giving a really nice overview of a

21

00:00:55,460 --> 00:00:52,470

geologic time scale so I don't have to

22

00:00:58,130 --> 00:00:55,470

go into all those details so pictured

23

00:01:01,340 --> 00:00:58,140

here is our general currently understood

24

00:01:03,160 --> 00:01:01,350

model of earth oxygenation and so what

25

00:01:05,719 --> 00:01:03,170

we see is that really the first

26
00:01:07,459 --> 00:01:05,729
accumulation of oxygen in the atmosphere

27
00:01:08,870 --> 00:01:07,469
occurred at about two and a half billion

28
00:01:11,719 --> 00:01:08,880
years ago this is the great oxidation

29
00:01:13,160 --> 00:01:11,729
event that's very well known but today

30
00:01:14,990 --> 00:01:13,170
I'm going to be focusing on this more

31
00:01:17,810 --> 00:01:15,000
recent time here this is two billion

32
00:01:20,750 --> 00:01:17,820
years later so this isn't a time period

33
00:01:23,270 --> 00:01:20,760
between the neoproterozoic and Cambrian

34
00:01:24,770 --> 00:01:23,280
transition and understanding the history

35
00:01:27,140 --> 00:01:24,780
of oxygenation during this time is

36
00:01:28,910 --> 00:01:27,150
particularly important because it's also

37
00:01:31,250 --> 00:01:28,920
at this time that we see in the fossil

38
00:01:33,170 --> 00:01:31,260

record the earliest evidence of a rapid

39

00:01:35,000 --> 00:01:33,180

diversification of oxygen breathing

40

00:01:38,719 --> 00:01:35,010

animals so this is otherwise known as

41

00:01:40,880 --> 00:01:38,729

the Cambrian explosion and so because of

42

00:01:43,219 --> 00:01:40,890

this this this general increase in

43

00:01:45,380 --> 00:01:43,229

oxygen during this time has been invoked

44

00:01:48,230 --> 00:01:45,390

as being potentially an environmental

45

00:01:50,060 --> 00:01:48,240

trigger of this evolution of increasing

46

00:01:51,130 --> 00:01:50,070

biological complexity this may or may

47

00:01:54,140 --> 00:01:51,140

not actually have been the case

48

00:01:56,270 --> 00:01:54,150

nevertheless in order to further explore

49

00:01:58,580 --> 00:01:56,280

the coevolution of life in the physical

50

00:02:00,620 --> 00:01:58,590

environment during this time as well as

51
00:02:02,420 --> 00:02:00,630
to understand the controlling factors of

52
00:02:04,429 --> 00:02:02,430
how we get the development and

53
00:02:06,859 --> 00:02:04,439
distribution of complex life both on our

54
00:02:08,869 --> 00:02:06,869
world and on other world it's necessary

55
00:02:10,520 --> 00:02:08,879
to better constrain both the magnitude

56
00:02:13,850 --> 00:02:10,530
and timing this history of oxygenation

57
00:02:16,010 --> 00:02:13,860
here so I will mention that this is a

58
00:02:16,970 --> 00:02:16,020
far from understudied area there are

59
00:02:18,710 --> 00:02:16,980
currently

60
00:02:20,479 --> 00:02:18,720
variety of both biological and

61
00:02:21,699 --> 00:02:20,489
geological proxies for understanding

62
00:02:24,649 --> 00:02:21,709
oxygenation during this time

63
00:02:27,589 --> 00:02:24,659

nevertheless though these various

64

00:02:29,300 --> 00:02:27,599

proxies do come with their associated

65

00:02:31,190 --> 00:02:29,310

strengths and uncertainties we're still

66

00:02:33,740 --> 00:02:31,200

left with a relatively qualitative view

67

00:02:35,720 --> 00:02:33,750

of oxygenation during this time and so

68

00:02:36,860 --> 00:02:35,730

it's our focus here to improve

69

00:02:39,199 --> 00:02:36,870

especially the quantitative

70

00:02:41,690 --> 00:02:39,209

understanding of particularly marine

71

00:02:43,400 --> 00:02:41,700

neoproterozoic and Cambrian oxygenation

72

00:02:45,530 --> 00:02:43,410

through the development of a more

73

00:02:48,949 --> 00:02:45,540

quantitative oxygen proxy or what we're

74

00:02:50,839 --> 00:02:48,959

calling an oxygen proxy barometer so

75

00:02:52,910 --> 00:02:50,849

what we've been looking at at the same

76

00:02:54,319 --> 00:02:52,920

time during this this increase in

77

00:02:56,360 --> 00:02:54,329

oxygenation we also see something

78

00:02:58,699 --> 00:02:56,370

special which is a neoproterozoic

79

00:03:00,949 --> 00:02:58,709

Cambrian phosphate Jenica vent and this

80

00:03:02,809 --> 00:03:00,959

is perhaps the largest and most globally

81

00:03:05,690 --> 00:03:02,819

extensive fossil genic event in Earth's

82

00:03:09,490 --> 00:03:05,700

history so what we see during phospho

83

00:03:11,960 --> 00:03:09,500

Genesis is the extensive global

84

00:03:14,030 --> 00:03:11,970

deposition of what are called phosphates

85

00:03:17,869 --> 00:03:14,040

so these are sediments for a phosphate

86

00:03:19,520 --> 00:03:17,879

rich geologic deposits for this time for

87

00:03:21,170 --> 00:03:19,530

the phosphates of these ages these are

88

00:03:23,240 --> 00:03:21,180

currently known from essentially every

89

00:03:24,379 --> 00:03:23,250

continent except Antarctica whether or

90

00:03:26,690 --> 00:03:24,389

not they're actually there and we just

91

00:03:27,860 --> 00:03:26,700

haven't found them we don't know so here

92

00:03:30,110 --> 00:03:27,870

you can see the geographic distribution

93

00:03:31,580 --> 00:03:30,120

as well as the age distribution down

94

00:03:33,229 --> 00:03:31,590

here on the bottom you can see that they

95

00:03:35,059 --> 00:03:33,239

cluster more or less within about 100

96

00:03:37,190 --> 00:03:35,069

million years of the neoproterozoic

97

00:03:38,780 --> 00:03:37,200

Cambrian boundary here and it's also

98

00:03:40,370 --> 00:03:38,790

important to note that for the most part

99

00:03:42,949 --> 00:03:40,380

these are shallow marine deposits and

100

00:03:46,159 --> 00:03:42,959

they contain abundant amounts of micro

101
00:03:47,780 --> 00:03:46,169
fossils ok so another reason why

102
00:03:49,430 --> 00:03:47,790
phosphates are important to study is

103
00:03:51,349 --> 00:03:49,440
that they concentrate phosphate in the

104
00:03:52,940 --> 00:03:51,359
mineral called apatite apatite is the

105
00:03:54,920 --> 00:03:52,950
same mineral that makes up our bones in

106
00:03:57,409 --> 00:03:54,930
our teeth if the calcium phosphate

107
00:03:59,930 --> 00:03:57,419
mineral and it's particularly well known

108
00:04:01,849 --> 00:03:59,940
in geology and that it incorporates a

109
00:04:04,339 --> 00:04:01,859
relatively high abundance of rare earth

110
00:04:05,960 --> 00:04:04,349
elements these are important typically

111
00:04:07,610 --> 00:04:05,970
in geologic applications because they

112
00:04:09,349 --> 00:04:07,620
usually carry with them some amount of

113
00:04:11,659 --> 00:04:09,359

petrographic and environmental

114

00:04:14,420 --> 00:04:11,669

information rare earth elements can

115

00:04:16,789 --> 00:04:14,430

substitute at two different calcium

116

00:04:18,140 --> 00:04:16,799

sites in the apatite structure two

117

00:04:20,060 --> 00:04:18,150

different sites very simply named the

118

00:04:21,860 --> 00:04:20,070

calcium one site and the calcium 2 site

119

00:04:24,860 --> 00:04:21,870

you can see from this figure that these

120

00:04:27,200 --> 00:04:24,870

- yeah very simple these two sites are

121

00:04:28,000 --> 00:04:27,210

different both in their local structural

122

00:04:30,940 --> 00:04:28,010

geometry

123

00:04:32,290 --> 00:04:30,950

symmetry but the problem occurs that

124

00:04:34,330 --> 00:04:32,300

rare earth elements are typically

125

00:04:36,670 --> 00:04:34,340

existing in the trivalent state and so

126

00:04:40,180 --> 00:04:36,680

in order to substitute a trivalent rare

127

00:04:42,100 --> 00:04:40,190

earth element in for a divalent calcium

128

00:04:44,800 --> 00:04:42,110

ion you have to go through a very

129

00:04:47,200 --> 00:04:44,810

particular substitution mechanism and so

130

00:04:49,390 --> 00:04:47,210

both observational and experimental

131

00:04:51,130 --> 00:04:49,400

evidence that suggested that at the

132

00:04:52,960 --> 00:04:51,140

calcium one site you get the

133

00:04:54,730 --> 00:04:52,970

substitution of a trivalent rare earth

134

00:04:56,740 --> 00:04:54,740

element for calcium through the

135

00:04:58,960 --> 00:04:56,750

incorporation of an additional vacancy

136

00:05:00,910 --> 00:04:58,970

so and in that sense you're essentially

137

00:05:03,520 --> 00:05:00,920

substituting two rare earth elements for

138

00:05:05,350 --> 00:05:03,530

three calcium ions but for the calcium

139

00:05:07,780 --> 00:05:05,360

to site this is where it becomes special

140

00:05:09,250 --> 00:05:07,790

for for our purposes is you get this

141

00:05:12,640 --> 00:05:09,260

double substitution of a rare earth

142

00:05:15,100 --> 00:05:12,650

element for calcium ion accompanying a

143

00:05:17,770 --> 00:05:15,110

substitution of an oxygen ion for a

144

00:05:19,210 --> 00:05:17,780

native anion usually with the case of

145

00:05:21,730 --> 00:05:19,220

apatite it's typically fluoride

146

00:05:23,680 --> 00:05:21,740

hydroxide or chloride and so it's here

147

00:05:25,810 --> 00:05:23,690

that we see in oxygen dependent

148

00:05:28,930 --> 00:05:25,820

mechanism pretty incorporation of rare

149

00:05:30,250 --> 00:05:28,940

earth elements and apatite so another

150

00:05:32,080 --> 00:05:30,260

thing that happens when you get birth

151
00:05:34,930 --> 00:05:32,090
elements into apatite is you make that

152
00:05:36,970 --> 00:05:34,940
apatite fluorescent so pictured here are

153
00:05:39,360 --> 00:05:36,980
two different fluorescence spectra this

154
00:05:42,730 --> 00:05:39,370
is a oops sorry this is a figure from

155
00:05:45,310 --> 00:05:42,740
gas pedal and so what they did was they

156
00:05:47,080 --> 00:05:45,320
artificially substituted samarium in

157
00:05:49,780 --> 00:05:47,090
apatite mineral and so the way you

158
00:05:51,040 --> 00:05:49,790
accomplish this is you take apatite and

159
00:05:52,660 --> 00:05:51,050
you take a source of Sumeria and you

160
00:05:55,780 --> 00:05:52,670
heat them to a high temperature in close

161
00:05:57,400 --> 00:05:55,790
proximity and that therefore facilitates

162
00:06:00,070 --> 00:05:57,410
the diffusion of samarium into the

163
00:06:02,050 --> 00:06:00,080

apatite crystal structure it measured

164

00:06:04,000 --> 00:06:02,060

them using fluorescence spectroscopy and

165

00:06:05,680 --> 00:06:04,010

they they did this heating experiment

166

00:06:07,120 --> 00:06:05,690

under two different conditions and so

167

00:06:08,740 --> 00:06:07,130

these two fluorescence spectra are

168

00:06:12,100 --> 00:06:08,750

representative of those two conditions

169

00:06:15,040 --> 00:06:12,110

in the red they did this heating process

170

00:06:16,570 --> 00:06:15,050

in a vacuum therefore resulting in the

171

00:06:19,420 --> 00:06:16,580

substitution of samarium in the calcium

172

00:06:22,210 --> 00:06:19,430

one site and they also did this with the

173

00:06:23,620 --> 00:06:22,220

green spectrum in air and so with this

174

00:06:26,080 --> 00:06:23,630

case you get the substitution of

175

00:06:29,140 --> 00:06:26,090

samarium the calcium to site in an

176

00:06:30,700 --> 00:06:29,150

oxygen dependent manner and so for these

177

00:06:33,370 --> 00:06:30,710

fluorescence spectra the spectral

178

00:06:35,440 --> 00:06:33,380

variability which is inherent to the the

179

00:06:37,390 --> 00:06:35,450

local structural effects of the calcium

180

00:06:39,790 --> 00:06:37,400

sites where samarium is substituting

181

00:06:41,980 --> 00:06:39,800

this really depends the variability

182

00:06:45,460 --> 00:06:41,990

depends on the presence of oxygen there

183

00:06:47,560 --> 00:06:45,470

samarium substitution okay so for the

184

00:06:49,150 --> 00:06:47,570

development of an appetite auction paleo

185

00:06:50,530 --> 00:06:49,160

barometer that takes advantage of this

186

00:06:52,930 --> 00:06:50,540

process we followed the following

187

00:06:54,880 --> 00:06:52,940

strategy the first is an experimental

188

00:06:56,890 --> 00:06:54,890

calibration of this fluorescence

189

00:06:58,480 --> 00:06:56,900

variability and so we've followed the

190

00:07:01,150 --> 00:06:58,490

same process of artificially

191

00:07:03,340 --> 00:07:01,160

substituting samarium and apatite under

192

00:07:05,650 --> 00:07:03,350

varying oxygen concentrations and then

193

00:07:08,560 --> 00:07:05,660

we follow that with the development of a

194

00:07:11,140 --> 00:07:08,570

quantifiable metric for assessing that

195

00:07:13,510 --> 00:07:11,150

spectral variability and then we took

196

00:07:16,150 --> 00:07:13,520

that metric and applied them to natural

197

00:07:17,650 --> 00:07:16,160

neoproterozoic and Cambrian age appetite

198

00:07:19,900 --> 00:07:17,660

specimens in order to then back

199

00:07:23,050 --> 00:07:19,910

calculate an estimate past local oxygen

200

00:07:24,790 --> 00:07:23,060

and so all of this with the general goal

201
00:07:28,240 --> 00:07:24,800
of really quantifying shallow marine

202
00:07:29,980 --> 00:07:28,250
oxygenation during this event okay so

203
00:07:32,440 --> 00:07:29,990
for the experimental calibration into

204
00:07:35,530 --> 00:07:32,450
the following so we we took these

205
00:07:37,870 --> 00:07:35,540
apatite powder and samarium pellets and

206
00:07:39,970 --> 00:07:37,880
compressed them heated them in a furnace

207
00:07:42,130 --> 00:07:39,980
in 900 degrees Celsius under varying

208
00:07:44,050 --> 00:07:42,140
levels of oxygen and then measured them

209
00:07:46,900 --> 00:07:44,060
using fluorescence spectroscopy and so

210
00:07:48,940 --> 00:07:46,910
what we see is this spectral variability

211
00:07:50,650 --> 00:07:48,950
that's transition from zero percent

212
00:07:52,900 --> 00:07:50,660
oxygen available to twenty percent

213
00:07:55,210 --> 00:07:52,910

oxygen this is just our current air

214

00:07:56,890 --> 00:07:55,220

composition and so we see is this

215

00:07:59,110 --> 00:07:56,900

transition and spectral character

216

00:08:00,430 --> 00:07:59,120

particularly in these two spectral

217

00:08:03,160 --> 00:08:00,440

ranges that are highlighted in these

218

00:08:05,470 --> 00:08:03,170

colored bars more specifically what we

219

00:08:07,450 --> 00:08:05,480

see is that as you go towards more

220

00:08:10,420 --> 00:08:07,460

anoxic experimental conditions you see

221

00:08:13,990 --> 00:08:10,430

the the increased intensity of

222

00:08:16,660 --> 00:08:14,000

fluorescence Peaks at the 607 and 654

223

00:08:18,220 --> 00:08:16,670

nanometer wavelength positions indicated

224

00:08:21,220 --> 00:08:18,230

by these red bars hope you can see them

225

00:08:23,380 --> 00:08:21,230

and as you go towards more toxic

226

00:08:25,300 --> 00:08:23,390

experimental conditions you instead see

227

00:08:28,720 --> 00:08:25,310

the increasing intensity of bands at the

228

00:08:30,880 --> 00:08:28,730

605 and 650 tune animated regions and so

229

00:08:33,130 --> 00:08:30,890

here you get samarium substitution the

230

00:08:34,540 --> 00:08:33,140

calcium one site and for the oxy case

231

00:08:37,390 --> 00:08:34,550

you get Sumerian substitution or the

232

00:08:38,650 --> 00:08:37,400

calcium 2 site and so for the for the

233

00:08:41,140 --> 00:08:38,660

rest of the talk will be kind of talking

234

00:08:42,970 --> 00:08:41,150

about these bands as oxid associated

235

00:08:44,620 --> 00:08:42,980

fluorescence signatures and these are

236

00:08:47,860 --> 00:08:44,630

anoxic associated fluorescence

237

00:08:50,140 --> 00:08:47,870

signatures ok so in order to quantify

238

00:08:51,760 --> 00:08:50,150

the spectral variability we followed a

239

00:08:54,700 --> 00:08:51,770

relatively standard peak fitting

240

00:08:55,390 --> 00:08:54,710

procedure where we are interested in in

241

00:08:57,760 --> 00:08:55,400

a sense ray

242

00:09:00,360 --> 00:08:57,770

showing the relative intensities of

243

00:09:03,280 --> 00:09:00,370

these ox ic and anoxic associative Peaks

244

00:09:04,810 --> 00:09:03,290

so did this really simple calculation

245

00:09:07,210 --> 00:09:04,820

it's just the area of an ox ik

246

00:09:09,880 --> 00:09:07,220

associated peak divided by the sum

247

00:09:12,370 --> 00:09:09,890

Daria's of a neighboring anoxic

248

00:09:14,230 --> 00:09:12,380

associate began the oxy peak and so what

249

00:09:16,600 --> 00:09:14,240

you get what we're calling is an

250

00:09:18,370 --> 00:09:16,610

appetite auction paleo barometer at AOP

251
00:09:20,410 --> 00:09:18,380
value somewhere between zero and one

252
00:09:22,510 --> 00:09:20,420
where a value of zero would indicate

253
00:09:25,750 --> 00:09:22,520
only the presence of these anoxic

254
00:09:28,060 --> 00:09:25,760
associated Peaks a value of sorry value

255
00:09:29,950 --> 00:09:28,070
of zero yes and the value of one would

256
00:09:32,560 --> 00:09:29,960
indicate the presence of only the oxic

257
00:09:36,310 --> 00:09:32,570
associated piece if you then plot these

258
00:09:38,200 --> 00:09:36,320
AOP values against the percentage oxygen

259
00:09:40,810 --> 00:09:38,210
that we used in the experiments we see a

260
00:09:43,180 --> 00:09:40,820
good agreement between these two these Q

261
00:09:44,890 --> 00:09:43,190
values and we also see this kind of

262
00:09:49,030 --> 00:09:44,900
characteristic curve here where we see a

263
00:09:51,160 --> 00:09:49,040

very steep slope between aoki values and

264

00:09:54,030 --> 00:09:51,170

oxygen the very low oxygen levels and

265

00:09:56,980 --> 00:09:54,040

then it sort of tapers off in plateaus

266

00:09:58,510 --> 00:09:56,990

okay so that that curve is essentially

267

00:10:00,220 --> 00:09:58,520

the calibration curve that we're using

268

00:10:02,770 --> 00:10:00,230

to compare with a natural appetite

269

00:10:04,600 --> 00:10:02,780

samples so going back here we've

270

00:10:05,950 --> 00:10:04,610

selected appetite specimens from three

271

00:10:08,950 --> 00:10:05,960

different geologic localities of

272

00:10:10,330 --> 00:10:08,960

neoproterozoic and Cambrian age so

273

00:10:12,700 --> 00:10:10,340

specifically we've looked at two

274

00:10:14,440 --> 00:10:12,710

phosphate localities so we've looked at

275

00:10:16,180 --> 00:10:14,450

samples from the late neopor to reserve

276
00:10:18,610 --> 00:10:16,190
through Shantou formations this is right

277
00:10:20,350 --> 00:10:18,620
before the boundary between the

278
00:10:22,000 --> 00:10:20,360
neoproterozoic and Cambrian and we also

279
00:10:24,670 --> 00:10:22,010
looked at the early cambrian shellac so

280
00:10:26,950 --> 00:10:24,680
formation of self cosmic Sun in addition

281
00:10:29,530 --> 00:10:26,960
to these two phosphate samples we also

282
00:10:31,300 --> 00:10:29,540
looked at a different one this is a this

283
00:10:33,610 --> 00:10:31,310
is a 15-mile group assist me

284
00:10:35,890 --> 00:10:33,620
neoproterozoic at the locality right at

285
00:10:37,900 --> 00:10:35,900
the Alaska Yukon border this is

286
00:10:40,660 --> 00:10:37,910
unrelated to foster it's actually sort

287
00:10:42,190 --> 00:10:40,670
of special this is the samples that I'll

288
00:10:44,050 --> 00:10:42,200

be talking about here have been

289

00:10:47,040 --> 00:10:44,060

interpreted to be really the earliest

290

00:10:49,630 --> 00:10:47,050

evidence of bio mineral apatite

291

00:10:52,150 --> 00:10:49,640

formation so these are fossil protists

292

00:10:53,410 --> 00:10:52,160

skeletal scales that are made of apatite

293

00:10:58,630 --> 00:10:53,420

so this is really fundamentally

294

00:10:59,890 --> 00:10:58,640

different than these two okay so to give

295

00:11:01,780 --> 00:10:59,900

you a better sense of what sorts of

296

00:11:03,070 --> 00:11:01,790

specimens we're looking at for the

297

00:11:05,580 --> 00:11:03,080

phosphorus would dushyant's from the

298

00:11:07,870 --> 00:11:05,590

chillax oh we looked at primarily at the

299

00:11:08,510 --> 00:11:07,880

apatite concreted wood so these are a

300

00:11:11,390 --> 00:11:08,520

little gray

301
00:11:12,920 --> 00:11:11,400
that chemically precipitated and Ryan's

302
00:11:15,440 --> 00:11:12,930
you get them now made of calcium

303
00:11:16,790 --> 00:11:15,450
carbonate say in the Bahamas and then we

304
00:11:19,400 --> 00:11:16,800
also looked at a variety of pure

305
00:11:21,740 --> 00:11:19,410
mineralized apatite fossils including

306
00:11:24,470 --> 00:11:21,750
sign of bacteria and animal embryos and

307
00:11:26,330 --> 00:11:24,480
here these are the fossils from the

308
00:11:28,760 --> 00:11:26,340
15-mile group so these have been

309
00:11:30,950 --> 00:11:28,770
interpreted as biologically controlled

310
00:11:33,470 --> 00:11:30,960
apatite mineralization from protists so

311
00:11:35,390 --> 00:11:33,480
these are these scale fossils um and I

312
00:11:37,040 --> 00:11:35,400
also want to mention that with all of

313
00:11:39,110 --> 00:11:37,050

these specimens they also carry with

314

00:11:41,060 --> 00:11:39,120

them a good deal of contextual geologic

315

00:11:43,280 --> 00:11:41,070

information so particularly with the

316

00:11:45,620 --> 00:11:43,290

phosphates we know that we're well

317

00:11:49,640 --> 00:11:45,630

constrained to a really shallow marine

318

00:11:51,590 --> 00:11:49,650

environment we know that apatite formed

319

00:11:54,020 --> 00:11:51,600

quite early potentially on the order of

320

00:11:55,700 --> 00:11:54,030

weeks fallen burial and then

321

00:11:57,980 --> 00:11:55,710

specifically for the phosphates we know

322

00:11:59,960 --> 00:11:57,990

we're sampling the shallow sediment

323

00:12:02,360 --> 00:11:59,970

deposition environment but in the case

324

00:12:04,100 --> 00:12:02,370

with a bio mineral learn step sampling

325

00:12:07,880 --> 00:12:04,110

kind of a lark column where the organism

326

00:12:10,160 --> 00:12:07,890

potentially lives in the past okay so we

327

00:12:12,590 --> 00:12:10,170

can also analyze these apatite specimens

328

00:12:14,420 --> 00:12:12,600

spectroscopically so here our average

329

00:12:17,330 --> 00:12:14,430

fluorescence spectra for each of these

330

00:12:19,670 --> 00:12:17,340

three geologic localities and so if we

331

00:12:21,530 --> 00:12:19,680

calculate them their associated ALP

332

00:12:23,510 --> 00:12:21,540

values but we get these are the three

333

00:12:25,820 --> 00:12:23,520

average aoki values for the three

334

00:12:27,770 --> 00:12:25,830

different localities and really the main

335

00:12:31,370 --> 00:12:27,780

takeaway here is that they all generally

336

00:12:33,620 --> 00:12:31,380

fall below a o P values of about 0.5 and

337

00:12:35,720 --> 00:12:33,630

so if we are to directly compare this to

338

00:12:38,960 --> 00:12:35,730

the experimental calibration curve we

339

00:12:41,830 --> 00:12:38,970

would then infer relatively low local

340

00:12:44,840 --> 00:12:41,840

oxygen in the surrounding environment

341

00:12:46,970 --> 00:12:44,850

but we do also see a relatively

342

00:12:49,730 --> 00:12:46,980

significant difference particularly with

343

00:12:51,350 --> 00:12:49,740

these two phosphate samples and so we

344

00:12:54,410 --> 00:12:51,360

could potentially interpret that as

345

00:12:55,850 --> 00:12:54,420

suggesting that the qu lacto sediment

346

00:12:57,650 --> 00:12:55,860

shallow sediment environment was

347

00:13:00,560 --> 00:12:57,660

potentially more oxygenated than that of

348

00:13:02,600 --> 00:13:00,570

the Santo and if we consider this

349

00:13:04,520 --> 00:13:02,610

history of increased oxygenation between

350

00:13:08,840 --> 00:13:04,530

the neoproterozoic and Cambrian this is

351

00:13:10,460 --> 00:13:08,850

relatively promising so finally I just

352

00:13:12,770 --> 00:13:10,470

want to mention these other apatite

353

00:13:14,450 --> 00:13:12,780

specimens which are unique to the chill

354

00:13:17,240 --> 00:13:14,460

act oh these are really beautifully

355

00:13:19,310 --> 00:13:17,250

preserved you he drill apatite crystals

356

00:13:22,249 --> 00:13:19,320

that are actually encrusting on the

357

00:13:24,859 --> 00:13:22,259

micro fossils themselves and so because

358

00:13:26,569 --> 00:13:24,869

it's a more well-organized crystalline

359

00:13:28,429 --> 00:13:26,579

form of apatite we can actually image

360

00:13:30,499 --> 00:13:28,439

them with decent resolution using

361

00:13:34,219 --> 00:13:30,509

fluorescence spectroscopic techniques

362

00:13:36,409 --> 00:13:34,229

and so maps here in green is the spatial

363

00:13:38,359 --> 00:13:36,419

distribution of these oxic related

364

00:13:40,009 --> 00:13:38,369

fluorescence signatures and in red is

365

00:13:43,009 --> 00:13:40,019

the spatial distribution of these an

366

00:13:45,679 --> 00:13:43,019

toxic associated fluorescence features

367

00:13:49,219 --> 00:13:45,689

so we see it this patterning where the

368

00:13:51,679 --> 00:13:49,229

crystal has this oxic core surrounded by

369

00:13:53,419 --> 00:13:51,689

an anoxic rind and we can do this three

370

00:13:56,090 --> 00:13:53,429

dimensionally and so you can see if we

371

00:13:58,759 --> 00:13:56,100

then rotate this and software and just

372

00:13:59,989 --> 00:13:58,769

cut through a slice down the center here

373

00:14:01,849 --> 00:13:59,999

and rotate it you can see that this

374

00:14:04,639 --> 00:14:01,859

patterning also continues with depth

375

00:14:07,819 --> 00:14:04,649

through the crystal we can do a point

376

00:14:10,609 --> 00:14:07,829

spectral transect from the interior to

377

00:14:12,949 --> 00:14:10,619

the exterior from a through e calculate

378

00:14:15,229 --> 00:14:12,959

the Associated AP values and we see that

379

00:14:16,909 --> 00:14:15,239

we get the same pattern of increased a

380

00:14:18,499 --> 00:14:16,919

row P values in the center indicating

381

00:14:21,109 --> 00:14:18,509

greater amounts of oxygen during the

382

00:14:23,629 --> 00:14:21,119

crystal formation and decreasing a hopi

383

00:14:26,449 --> 00:14:23,639

values through to the exterior and so

384

00:14:29,150 --> 00:14:26,459

this patterning is is very reminiscent

385

00:14:31,340 --> 00:14:29,160

of a well known phenomenon for crystal

386

00:14:32,599 --> 00:14:31,350

growth called concentric zonation and so

387

00:14:34,309 --> 00:14:32,609

what this happens is you get this

388

00:14:37,579 --> 00:14:34,319

chemical change as the crystal grows

389

00:14:39,439 --> 00:14:37,589

from the center to the outside and so if

390

00:14:41,689 --> 00:14:39,449

that is the case and potentially this

391

00:14:43,789 --> 00:14:41,699

donation pattern is indicative of

392

00:14:45,590 --> 00:14:43,799

increasing local anoxia during crystal

393

00:14:49,369 --> 00:14:45,600

growth and phosphor eye burial and this

394

00:14:51,349 --> 00:14:49,379

makes a good deal with them okay so as I

395

00:14:53,569 --> 00:14:51,359

come to a close I just do want to

396

00:14:55,909 --> 00:14:53,579

mention an important caveat which is

397

00:14:58,069 --> 00:14:55,919

probably the most obvious which is that

398

00:15:00,169 --> 00:14:58,079

our experimental heat substituted

399

00:15:01,939 --> 00:15:00,179

apatite is perhaps not absolutely

400

00:15:04,309 --> 00:15:01,949

directly analogous to aqueous

401
00:15:07,249 --> 00:15:04,319
precipitation of apatite in a marine

402
00:15:09,379 --> 00:15:07,259
environment but I do want to mention we

403
00:15:10,939 --> 00:15:09,389
would argue that really the oxygen

404
00:15:13,340 --> 00:15:10,949
dependent mechanism that we're tracking

405
00:15:15,649 --> 00:15:13,350
here isn't very inherent to the apatite

406
00:15:17,090 --> 00:15:15,659
structure itself in this apatite these

407
00:15:19,639 --> 00:15:17,100
features of the apatite structure are

408
00:15:21,739 --> 00:15:19,649
constant regardless and so we still see

409
00:15:23,629 --> 00:15:21,749
the strong potential for increased

410
00:15:25,849 --> 00:15:23,639
quantitative refinement of this paleo

411
00:15:28,489 --> 00:15:25,859
barometer whether or not the actual

412
00:15:31,879 --> 00:15:28,499
specific scaling of these AOP values and

413
00:15:33,859 --> 00:15:31,889

oxygen remain exactly the same and so

414

00:15:34,650 --> 00:15:33,869

moving forward what we really need to

415

00:15:36,809 --> 00:15:34,660

see

416

00:15:38,639 --> 00:15:36,819

similar oxygen controlled experiments

417

00:15:40,379 --> 00:15:38,649

that instead of doing this heat

418

00:15:44,129 --> 00:15:40,389

substitution we have actual aqueous

419

00:15:46,410 --> 00:15:44,139

precipitation and so with that we would

420

00:15:48,829 --> 00:15:46,420

then be able to more directly relate a

421

00:15:50,009 --> 00:15:48,839

or P values to local dissolved oxygen

422

00:15:53,129 --> 00:15:50,019

concentrations

423

00:15:55,050 --> 00:15:53,139

I also want to mention which is also

424

00:15:57,090 --> 00:15:55,060

exciting is that samarium which we

425

00:15:58,530 --> 00:15:57,100

focused on here is not the only rare

426
00:16:00,240 --> 00:15:58,540
earth element that has been suggested to

427
00:16:02,460 --> 00:16:00,250
be related to these oxygen dependent

428
00:16:04,410 --> 00:16:02,470
mechanisms for that incorporation into

429
00:16:06,509 --> 00:16:04,420
apatite so you know you could

430
00:16:07,800 --> 00:16:06,519
potentially envision an entire suite of

431
00:16:09,389 --> 00:16:07,810
rare earth elements that are each

432
00:16:12,809 --> 00:16:09,399
through their fluorescence signatures

433
00:16:14,819 --> 00:16:12,819
independently corroborating these oxygen

434
00:16:16,170 --> 00:16:14,829
related signatures and finally as I

435
00:16:18,749 --> 00:16:16,180
showed in that map there are numerous

436
00:16:21,090 --> 00:16:18,759
other phosphates of varying age leading

437
00:16:22,379 --> 00:16:21,100
up through the neoproterozoic membrane

438
00:16:25,319 --> 00:16:22,389

and oxygenation this so there are

439

00:16:29,280 --> 00:16:25,329

potentially a whole slew of samples to

440

00:16:30,540 --> 00:16:29,290

apply these these procedures - okay so

441

00:16:32,189 --> 00:16:30,550

with that I'm just going to leave these

442

00:16:33,689 --> 00:16:32,199

very broad conclusions up here and I'll

443

00:16:43,019 --> 00:16:33,699

be happy to take any questions so thank

444

00:16:50,400 --> 00:16:43,029

you very much Thank You Amanda any

445

00:16:51,600 --> 00:16:50,410

questions thank you for that like it was

446

00:16:53,280 --> 00:16:51,610

really cool yeah

447

00:16:54,809 --> 00:16:53,290

I was just wondering have you been able

448

00:16:56,550 --> 00:16:54,819

to look at the zonation in modern

449

00:16:59,460 --> 00:16:56,560

samples that you can actually control

450

00:17:00,269 --> 00:16:59,470

the oxygen amounts of to see if they

451

00:17:01,829 --> 00:17:00,279

also occur

452

00:17:03,689 --> 00:17:01,839

yeah we would we would like to look at

453

00:17:11,809 --> 00:17:03,699

modern samples unfortunately we haven't