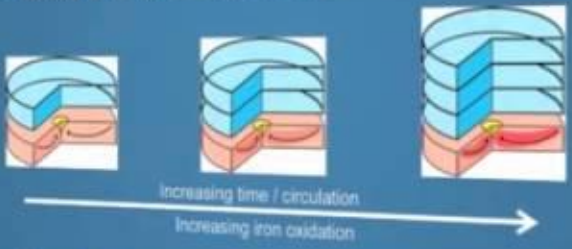
Calculation Methods

- Treat hydrothermal cell as a cylinder of 6 km diameter x 1 km thick
- Initial Fe^{3+}/Fe^{2+} ratio: 0.2



- Final Fe^{3+}/Fe^{2+} ratio: 2.5
- Total moles of Fe oxidized: 4.3×10^{13}

1
00:00:12,110 --> 00:00:09,740
just like jessa done i'm also a my

2
00:00:13,370 --> 00:00:12,120
background is in or geology and so what

3
00:00:15,529 --> 00:00:13,380
I'm hoping to do is take some of the

4
00:00:17,960 --> 00:00:15,539
techniques that we use in our field and

5
00:00:20,720 --> 00:00:17,970
kind of apply them and some of the very

6
00:00:22,970 --> 00:00:20,730
different approaches we have to looking

7
00:00:26,689 --> 00:00:22,980
at geology and see what can that tell us

8
00:00:28,550 --> 00:00:26,699
in the astrobiology field so again I we

9
00:00:29,720 --> 00:00:28,560
have a lot of corporate sponsors mostly

10
00:00:33,590 --> 00:00:29,730
because they let us access to their

11
00:00:34,910 --> 00:00:33,600
field site so right so to start off I'm

12
00:00:37,700 --> 00:00:34,920
going to be talking about our key and

13
00:00:39,709 --> 00:00:37,710

sulfate in particular and so I'm talking

14
00:00:42,200 --> 00:00:39,719
about our kyun I'm talking pre 2.4

15
00:00:44,869 --> 00:00:42,210
billion years and this is the big

16
00:00:47,630 --> 00:00:44,879
disclaimer alert so some of the earlier

17
00:00:49,700 --> 00:00:47,640
talks you've heard about the great

18
00:00:53,090 --> 00:00:49,710
oxidation event the rise of oxygen at

19
00:00:56,180 --> 00:00:53,100
2.4 billion years I do not fall under

20
00:00:58,160 --> 00:00:56,190
that school of thought and so what I'm

21
00:01:00,110 --> 00:00:58,170
actually presenting here is showing some

22
00:01:01,549 --> 00:01:00,120
of the techniques and actually one of

23
00:01:04,160 --> 00:01:01,559
the ways we've gone through and done

24
00:01:05,710 --> 00:01:04,170
some modeling to kind of say why we

25
00:01:07,310 --> 00:01:05,720
don't put that rise of oxygen and

26
00:01:09,380 --> 00:01:07,320
particularly some of these other

27
00:01:11,240 --> 00:01:09,390
interesting redox-sensitive elements why

28
00:01:14,179 --> 00:01:11,250
we don't believe that balls at 2.4

29
00:01:15,560 --> 00:01:14,189
billion years so in particular I'm going

30
00:01:17,450 --> 00:01:15,570
to be talking about sulfate we care

31
00:01:19,940 --> 00:01:17,460
about sulfate very important for biology

32
00:01:21,920 --> 00:01:19,950
very important for a lot of the redox

33
00:01:24,310 --> 00:01:21,930
chemistry that we're interested in and

34
00:01:27,469 --> 00:01:24,320
really important for making shiny medals

35
00:01:29,300 --> 00:01:27,479
so current consensus right now is that

36
00:01:30,380 --> 00:01:29,310
if you have this an toxic archaean it's

37
00:01:32,270 --> 00:01:30,390
really hard to have sulfate

38
00:01:34,280 --> 00:01:32,280

concentrations greater than about point

39
00:01:36,800 --> 00:01:34,290
1 millimolar that's based off of things

40
00:01:38,719 --> 00:01:36,810
like sulfur isotope evidence that use

41
00:01:41,660 --> 00:01:38,729
just simply if you look at the archaean

42
00:01:43,210 --> 00:01:41,670
it should be hard to get that sulfur

43
00:01:46,039 --> 00:01:43,220
Delphic concentrations greater than that

44
00:01:48,080 --> 00:01:46,049
however we start looking at the actual

45
00:01:49,969 --> 00:01:48,090
geologic record there starts to be some

46
00:01:53,090 --> 00:01:49,979
major problems first and foremost this

47
00:01:55,249 --> 00:01:53,100
is the dresser formation it's 3.44 nine

48
00:01:58,219 --> 00:01:55,259
ish billion years old it's a multi

49
00:02:00,319 --> 00:01:58,229
million metric ton barium sulfate

50
00:02:01,850 --> 00:02:00,329
deposit and that's very hard to do if

51
00:02:04,340 --> 00:02:01,860
you have very little sulfate in your

52
00:02:06,230 --> 00:02:04,350
oceans doing the calculations if you

53
00:02:08,690 --> 00:02:06,240
take about that much it requires almost

54
00:02:11,270 --> 00:02:08,700
an entire world's ocean to evaporate to

55
00:02:12,800 --> 00:02:11,280
make that much of a bedded salt bed so

56
00:02:15,470 --> 00:02:12,810
that's one problem the other thing is

57
00:02:16,760 --> 00:02:15,480
from our actual or deposit itself i'm

58
00:02:18,560 --> 00:02:16,770
working on a hydrothermal system that

59
00:02:19,550 --> 00:02:18,570
i'll get into but we also have lots of

60
00:02:22,610 --> 00:02:19,560
barite in our stuff

61
00:02:24,170 --> 00:02:22,620
so this is an ex RF image the green

62
00:02:26,270 --> 00:02:24,180
sections is where we're going to be

63
00:02:27,740 --> 00:02:26,280

seeing that barium sulfate and you can

64
00:02:29,750 --> 00:02:27,750
see it's not equal to PI right so

65
00:02:32,120 --> 00:02:29,760
there's some interesting fluid chemistry

66
00:02:34,100 --> 00:02:32,130
of evolution kind of showing up there so

67
00:02:36,110 --> 00:02:34,110
in particular i'm interested in

68
00:02:39,470 --> 00:02:36,120
volcanogenic massive sulphides VMS

69
00:02:41,870 --> 00:02:39,480
systems unlike justice system where it's

70
00:02:44,210 --> 00:02:41,880
actually dealing with magma getting some

71
00:02:46,040 --> 00:02:44,220
exposure our system really doesn't

72
00:02:49,009 --> 00:02:46,050
actually make real contact with any

73
00:02:50,809 --> 00:02:49,019
liquid rock it's just heat that's

74
00:02:52,550 --> 00:02:50,819
percolating through sea floor so the

75
00:02:54,229 --> 00:02:52,560
wave EMS system works there analogous to

76
00:02:55,940 --> 00:02:54,239
the black smokers that everybody has

77
00:02:57,890 --> 00:02:55,950
been talking about what's happening is

78
00:02:59,680 --> 00:02:57,900
you're actually have ocean sea water

79
00:03:01,820 --> 00:02:59,690
percolates through fractures in the rock

80
00:03:03,500 --> 00:03:01,830
as its fracturing through there's some

81
00:03:04,699 --> 00:03:03,510
intrusive body be it a dike via the

82
00:03:06,350 --> 00:03:04,709
mid-ocean ridge setting something like

83
00:03:07,910 --> 00:03:06,360
that that's generating amount of heat

84
00:03:09,380 --> 00:03:07,920
that's going to actually drive that

85
00:03:11,390 --> 00:03:09,390
water through get the big circulation

86
00:03:14,000 --> 00:03:11,400
and as that water moves through we get

87
00:03:16,460 --> 00:03:14,010
all kinds of interesting reactions some

88
00:03:19,100 --> 00:03:16,470

are just simply moving metals actually

89
00:03:20,900 --> 00:03:19,110
making the massive sulfide that we're so

90
00:03:21,949 --> 00:03:20,910
interested in mining but some of the

91
00:03:23,810 --> 00:03:21,959
other stuff is actually doing

92
00:03:25,430 --> 00:03:23,820
interesting redox chemistry so one of

93
00:03:27,770 --> 00:03:25,440
the very very important reactions for

94
00:03:29,150 --> 00:03:27,780
VMS systems it generates a lot of the

95
00:03:31,849 --> 00:03:29,160
sulfide that's actually in that massive

96
00:03:33,860 --> 00:03:31,859
sulfide is seawater sulfate as it comes

97
00:03:37,490 --> 00:03:33,870
in contact with ferrous iron in these

98
00:03:38,690 --> 00:03:37,500
rocks at above 250 degrees if there's

99
00:03:40,430 --> 00:03:38,700
lots of ferrous iron which these are

100
00:03:42,259 --> 00:03:40,440
basalts that ferrous iron will actually

101
00:03:44,180 --> 00:03:42,269
become ferric iron in that seawater

102
00:03:45,650 --> 00:03:44,190
sulfate will actually become sulfide and

103
00:03:47,840 --> 00:03:45,660
so when you get that mutual

104
00:03:49,400 --> 00:03:47,850
thermochemical sulfate reduction you

105
00:03:51,500 --> 00:03:49,410
actually will get halos where you

106
00:03:54,199 --> 00:03:51,510
actually get some amount of increased

107
00:03:57,710 --> 00:03:54,209
ferric iron in this rocks and you'll get

108
00:03:59,629 --> 00:03:57,720
lots of sulfide in return so the actual

109
00:04:01,910 --> 00:03:59,639
site that I'm interested in it's known

110
00:04:04,009 --> 00:04:01,920
as the panorama district we're way up

111
00:04:06,259 --> 00:04:04,019
here in the far north western end of

112
00:04:08,030 --> 00:04:06,269
Western Australia the actual district is

113
00:04:10,340 --> 00:04:08,040

actually a cluster of multiple VMs

114
00:04:12,170 --> 00:04:10,350
systems and what's beautiful and really

115
00:04:14,059 --> 00:04:12,180
rare about this is it's actually cut on

116
00:04:15,199 --> 00:04:14,069
profile so usually when you're looking

117
00:04:17,210 --> 00:04:15,209
at these deposits unless you're actually

118
00:04:19,069 --> 00:04:17,220
in a mine you don't get to see what the

119
00:04:20,930 --> 00:04:19,079
circulation cell looked like but in this

120
00:04:22,400 --> 00:04:20,940
case if we actually look at this track

121
00:04:23,779 --> 00:04:22,410
column we would have laid down the

122
00:04:25,190 --> 00:04:23,789
basalts and everything like that that

123
00:04:27,560 --> 00:04:25,200
was being circulated through first and

124
00:04:29,480 --> 00:04:27,570
then this big straily granite pumped up

125
00:04:31,430 --> 00:04:29,490
through and as it did so it tilted

126
00:04:32,900 --> 00:04:31,440
everything about 90 degrees and that's

127
00:04:34,790 --> 00:04:32,910
really the end of where the main

128
00:04:36,650 --> 00:04:34,800
formation stopped so we actually have

129
00:04:38,540 --> 00:04:36,660
this beautifully preserved side view of

130
00:04:41,410 --> 00:04:38,550
these systems so we can actually look at

131
00:04:43,850 --> 00:04:41,420
the hydrothermal circulation cells now

132
00:04:45,470 --> 00:04:43,860
what's also important to know for it's a

133
00:04:47,600 --> 00:04:45,480
geology we get the obligation you know

134
00:04:49,640 --> 00:04:47,610
to show a field work photo what a mining

135
00:04:51,110 --> 00:04:49,650
company describes as a road is somewhat

136
00:04:52,910 --> 00:04:51,120
different than but you might describe as

137
00:04:55,940 --> 00:04:52,920
a road so it's an interesting place to

138
00:04:57,020 --> 00:04:55,950

do fieldwork and collect samples so what

139
00:04:59,150 --> 00:04:57,030
we've done though is we've actually

140
00:05:00,530 --> 00:04:59,160
collected large amounts of samples and

141
00:05:02,600 --> 00:05:00,540
we've analyzed them prepare at Ferris

142
00:05:03,680 --> 00:05:02,610
ratios so right this is kind of weird

143
00:05:05,300 --> 00:05:03,690
right we're going to be looking for

144
00:05:07,040 --> 00:05:05,310
sulphate concentrations but we're using

145
00:05:08,480 --> 00:05:07,050
iron well we're coming back to that

146
00:05:10,250 --> 00:05:08,490
actual reaction that we were talking

147
00:05:12,980 --> 00:05:10,260
about that's so important in VMs systems

148
00:05:15,260 --> 00:05:12,990
now we think we actually have a pretty

149
00:05:17,120 --> 00:05:15,270
good handle on VMS systems when we work

150
00:05:18,740 --> 00:05:17,130
with ore deposits because there's so

151
00:05:19,970 --> 00:05:18,750
much money in the line we understand

152
00:05:22,010 --> 00:05:19,980
them pretty well and we're pretty sure

153
00:05:23,480 --> 00:05:22,020
we actually have a good handle on not

154
00:05:24,800 --> 00:05:23,490
only the processes the temperatures

155
00:05:26,540 --> 00:05:24,810
involve the reaction rates that are

156
00:05:28,550 --> 00:05:26,550
involved so we think we can actually do

157
00:05:29,960 --> 00:05:28,560
a lot of modeling going forward so if I

158
00:05:31,880 --> 00:05:29,970
have a map like this where I've actually

159
00:05:33,080 --> 00:05:31,890
been able to say that yes there's

160
00:05:35,120 --> 00:05:33,090
actually an increase in the ferric

161
00:05:36,830 --> 00:05:35,130
various ratios around what we've

162
00:05:38,300 --> 00:05:36,840
actually deemed and a lot of authors

163
00:05:40,460 --> 00:05:38,310

have worked on and identified as the

164
00:05:42,410 --> 00:05:40,470
hydrothermal circulation cells but maybe

165
00:05:44,300 --> 00:05:42,420
we can actually use this barrack faris

166
00:05:45,800 --> 00:05:44,310
enrichment to actually say how much

167
00:05:47,390 --> 00:05:45,810
sulphate was required to circulate

168
00:05:50,270 --> 00:05:47,400
through the rock and therefore what was

169
00:05:52,520 --> 00:05:50,280
the seawater sulfate concentration so

170
00:05:54,350 --> 00:05:52,530
alteration geometry fortunately like I

171
00:05:55,790 --> 00:05:54,360
said we have this nice profile view so

172
00:05:58,040 --> 00:05:55,800
what we actually can do is we can kind

173
00:06:00,080 --> 00:05:58,050
of confine these slabs and if we do a

174
00:06:01,790 --> 00:06:00,090
simplified strat column most of our

175
00:06:04,130 --> 00:06:01,800
circulation occurred in these anti site

176
00:06:07,310 --> 00:06:04,140
basalt layers they're roughly tabular

177
00:06:08,720 --> 00:06:07,320
and frankly for it being 2.4 we're going

178
00:06:11,330 --> 00:06:08,730
to start assuming some simplified

179
00:06:14,480 --> 00:06:11,340
geometry it's something we do for a lot

180
00:06:16,790 --> 00:06:14,490
of a lot of these type of or systems

181
00:06:20,000 --> 00:06:16,800
it's we take simple shapes so in our

182
00:06:22,940 --> 00:06:20,010
case we chose a cylinder it's a fairly

183
00:06:25,159 --> 00:06:22,950
simple it's a fairly accurate assessment

184
00:06:26,300 --> 00:06:25,169
for doing these type of things we've

185
00:06:28,550 --> 00:06:26,310
done them for a lot of these types of

186
00:06:30,440 --> 00:06:28,560
ore deposits so what we're doing is

187
00:06:32,110 --> 00:06:30,450
we're going to assume a cylinder our

188
00:06:36,170 --> 00:06:32,120

circulation cells about 6 kilometers

189
00:06:38,540 --> 00:06:36,180
insert in diameter and so that cylinder

190
00:06:40,820 --> 00:06:38,550
of rock has some starting ferric very

191
00:06:43,159 --> 00:06:40,830
she o in our case we took pristine

192
00:06:44,800 --> 00:06:43,169
back-arc base and basalt that has a

193
00:06:46,879 --> 00:06:44,810
ferric various ratio of about point two

194
00:06:48,110 --> 00:06:46,889
it's a pretty fair assessment people

195
00:06:50,089 --> 00:06:48,120
have done a lot of identification on

196
00:06:52,219 --> 00:06:50,099
these basalts starting off with that

197
00:06:54,140 --> 00:06:52,229
it's an assumption but it seems like a

198
00:06:56,450 --> 00:06:54,150
pretty safe assumption is that's what

199
00:06:58,010 --> 00:06:56,460
our starting iron oxidation state is so

200
00:06:59,420 --> 00:06:58,020
what's going to happen is more and more

201
00:07:02,089 --> 00:06:59,430
sea water is going to circulate through

202
00:07:03,260 --> 00:07:02,099
this rock as time goes on and as as

203
00:07:04,610 --> 00:07:03,270
that's happening you're going to

204
00:07:07,249 --> 00:07:04,620
actually start increasing the iron

205
00:07:08,510 --> 00:07:07,259
oxidation state so from the actual data

206
00:07:11,510 --> 00:07:08,520
that we've measured we have a final

207
00:07:13,790 --> 00:07:11,520
faris ratio of about 2.5 so what we've

208
00:07:17,059 --> 00:07:13,800
actually done is we can say to get from

209
00:07:19,249 --> 00:07:17,069
here to here we have some huge number of

210
00:07:21,619 --> 00:07:19,259
moles of iron oxidized alright the

211
00:07:23,540 --> 00:07:21,629
number is not as important but we need

212
00:07:26,480 --> 00:07:23,550
it for our calculations so if we go back

213
00:07:27,860 --> 00:07:26,490

to our favorite reaction here what we

214
00:07:29,600 --> 00:07:27,870
can do is we take the number of moles of

215
00:07:31,100 --> 00:07:29,610
iron that we're actually oxidized we can

216
00:07:33,830 --> 00:07:31,110
come back and derive out how many moles

217
00:07:35,540 --> 00:07:33,840
of sulfate were required now that gives

218
00:07:37,820 --> 00:07:35,550
us a total amount of sulfur that does

219
00:07:40,249 --> 00:07:37,830
not actually give us actual ocean

220
00:07:41,779 --> 00:07:40,259
concentrations to do that we actually

221
00:07:42,769 --> 00:07:41,789
need to start thinking about how much

222
00:07:45,589 --> 00:07:42,779
would actually have to flow through the

223
00:07:47,450 --> 00:07:45,599
rock so when we do these hydrothermal

224
00:07:49,129 --> 00:07:47,460
systems just using the shear volumes of

225
00:07:50,990 --> 00:07:49,139
rock really cumbersome and bulky and

226
00:07:52,279 --> 00:07:51,000
doesn't make a lot of it doesn't work

227
00:07:54,499 --> 00:07:52,289
really well in your head so what we use

228
00:07:56,360 --> 00:07:54,509
is what we call water Rock units so what

229
00:07:59,029 --> 00:07:56,370
a rock unit is the mass of water to flow

230
00:08:01,010 --> 00:07:59,039
through the same mass of rock so just an

231
00:08:03,260 --> 00:08:01,020
easier unit to put your head and so we

232
00:08:05,540 --> 00:08:03,270
notice is and as you might expect that

233
00:08:08,329 --> 00:08:05,550
at very low sulphate concentrations it

234
00:08:10,040 --> 00:08:08,339
takes more units of this water at low

235
00:08:12,320 --> 00:08:10,050
sulphate concentrations to flow through

236
00:08:15,320 --> 00:08:12,330
it to generate that person that observed

237
00:08:17,089 --> 00:08:15,330
alteration however if we start

238
00:08:18,800 --> 00:08:17,099

increasing that sulphate concentration

239
00:08:21,139 --> 00:08:18,810
now it's certain to take smaller and

240
00:08:23,450 --> 00:08:21,149
smaller water Rock ratios now we're

241
00:08:25,879 --> 00:08:23,460
starting to actually can we kind of

242
00:08:28,399 --> 00:08:25,889
limit it in so again that doesn't

243
00:08:30,829 --> 00:08:28,409
actually this chart I have this

244
00:08:32,870 --> 00:08:30,839
highlighted but I'll show you why if we

245
00:08:33,980 --> 00:08:32,880
actually go to the actual deposits and

246
00:08:35,630 --> 00:08:33,990
we start looking at the alteration

247
00:08:37,579 --> 00:08:35,640
minerals it's really nice as we can

248
00:08:39,980 --> 00:08:37,589
actually say how much water has flown

249
00:08:41,420 --> 00:08:39,990
through there at temperature so when we

250
00:08:43,969 --> 00:08:41,430
actually look at the alteration minerals

251
00:08:46,579 --> 00:08:43,979
we can say that there was probably not

252
00:08:48,470 --> 00:08:46,589
more than 60 water Rock units flowing

253
00:08:50,060 --> 00:08:48,480
through that body they're simply the

254
00:08:51,860 --> 00:08:50,070
Clay's and the things we see there if

255
00:08:53,509 --> 00:08:51,870
you had more water flowing through it at

256
00:08:55,100 --> 00:08:53,519
higher temperatures you simply would not

257
00:08:58,370 --> 00:08:55,110
have preserved the mineral textures we

258
00:09:00,680 --> 00:08:58,380
see so using that as our limit well we

259
00:09:02,600 --> 00:09:00,690
see that just based on the hydrothermal

260
00:09:05,330 --> 00:09:02,610
alteration that we have a limit of about

261
00:09:07,280 --> 00:09:05,340
one millimeter the water that was

262
00:09:08,540 --> 00:09:07,290
flowing through these systems now

263
00:09:10,730 --> 00:09:08,550

there's another way we can go about

264
00:09:12,860 --> 00:09:10,740
looking at this I'd mentioned that these

265
00:09:14,990 --> 00:09:12,870
hydrothermal systems these VMs deposits

266
00:09:19,130 --> 00:09:15,000
are driven by some sort of intrusive

267
00:09:21,440 --> 00:09:19,140
heat body so if we take again our nice

268
00:09:23,660 --> 00:09:21,450
simplified cylinder there there needs to

269
00:09:25,370 --> 00:09:23,670
be some volume of intrusive below it

270
00:09:26,960 --> 00:09:25,380
that's supplying the heat that's

271
00:09:29,360 --> 00:09:26,970
actually going to be driving the system

272
00:09:31,640 --> 00:09:29,370
now Larry Catholics who's done a lot of

273
00:09:33,290 --> 00:09:31,650
work on these systems he's done all the

274
00:09:35,120 --> 00:09:33,300
very very complicated math but it really

275
00:09:37,610 --> 00:09:35,130
comes down to at the end of the day to

276
00:09:39,290 --> 00:09:37,620
heat 1 kilogram of seawater to 250

277
00:09:41,150 --> 00:09:39,300
degrees which is the requirement for

278
00:09:44,210 --> 00:09:41,160
this reaction to go forward you need

279
00:09:45,980 --> 00:09:44,220
point seven kilograms of melt so if we

280
00:09:47,510 --> 00:09:45,990
go back to looking at the actual water

281
00:09:50,090 --> 00:09:47,520
Rock ratios that we were talking about

282
00:09:53,240 --> 00:09:50,100
depending on sulfate concentrations we

283
00:09:55,370 --> 00:09:53,250
can actually say how thick of a the

284
00:09:58,670 --> 00:09:55,380
volume of melt has to be to actually

285
00:10:00,500 --> 00:09:58,680
drive this hydrothermal cell so if we're

286
00:10:03,140 --> 00:10:00,510
at sulphate concentrations less than say

287
00:10:05,420 --> 00:10:03,150
five millimolar you all of a sudden need

288
00:10:08,600 --> 00:10:05,430

a granitic intrusive that is now more

289
00:10:10,040 --> 00:10:08,610
than 10 kilometers thick well we've

290
00:10:11,690 --> 00:10:10,050
mapped and we've drilled the surly

291
00:10:13,640 --> 00:10:11,700
granite we know it's not actually larger

292
00:10:15,350 --> 00:10:13,650
than 10 kilometers thick so that right

293
00:10:17,570 --> 00:10:15,360
there is actually providing a limit that

294
00:10:20,150 --> 00:10:17,580
you needed to be able to actually flow

295
00:10:23,060 --> 00:10:20,160
water through this body and not quench

296
00:10:25,460 --> 00:10:23,070
the system so that's a suggesting that

297
00:10:27,560 --> 00:10:25,470
we're at least five millimolar sulfate

298
00:10:33,320 --> 00:10:27,570
in this contemporaneous arc en seawater

299
00:10:34,970 --> 00:10:33,330
now that's assuming at 250 degrees if we

300
00:10:36,110 --> 00:10:34,980
base on some of the metals that we see

301
00:10:37,910 --> 00:10:36,120
there are things like copper that

302
00:10:39,050 --> 00:10:37,920
require higher temperatures odds are

303
00:10:40,790 --> 00:10:39,060
we're actually going to probably move

304
00:10:42,770 --> 00:10:40,800
this even towards greater sulphate

305
00:10:45,950 --> 00:10:42,780
concentrations in this contemporaneous

306
00:10:47,090 --> 00:10:45,960
seawater so really what did we really

307
00:10:48,980 --> 00:10:47,100
see when we're going through these sites

308
00:10:50,630 --> 00:10:48,990
the first thing and foremost is if

309
00:10:53,180 --> 00:10:50,640
you're interested in are keen sulfate

310
00:10:55,460 --> 00:10:53,190
there's extensive sulfate mineralization

311
00:10:56,960 --> 00:10:55,470
it's all barium sulfate but frankly if

312
00:10:58,430 --> 00:10:56,970
you think about things like gypsum there

313
00:11:01,070 --> 00:10:58,440

to soluble they would not have been

314
00:11:03,290 --> 00:11:01,080
sitting around for 3 billion years we've

315
00:11:05,120 --> 00:11:03,300
observed very large ferric enrichments

316
00:11:07,130 --> 00:11:05,130
and they seem to be the result of

317
00:11:08,540 --> 00:11:07,140
sulfate reduction and when we looked at

318
00:11:10,220 --> 00:11:08,550
the actual alteration patterns in some

319
00:11:11,990 --> 00:11:10,230
of the thermal modeling we actually see

320
00:11:14,540 --> 00:11:12,000
that we're probably looking at at least

321
00:11:15,800 --> 00:11:14,550
125 millimolar zuv sulfate

322
00:11:19,100 --> 00:11:15,810
which is an order of magnitude greater

323
00:11:21,530 --> 00:11:19,110
than what people are proposing that

324
00:11:23,780 --> 00:11:21,540
should exist in that pre rise of oxygen

325
00:11:26,030 --> 00:11:23,790
archaean now kind of a teaser something

326
00:11:27,110 --> 00:11:26,040
I'm not presenting here yet but if we

327
00:11:28,970 --> 00:11:27,120
actually look at some of the other

328
00:11:31,430 --> 00:11:28,980
elements things like uranium tungsten

329
00:11:33,920 --> 00:11:31,440
chrome that are also redox-sensitive we

330
00:11:36,019 --> 00:11:33,930
actually see similar patterns to what

331
00:11:37,610 --> 00:11:36,029
we've seen here for the ferric ferric

332
00:11:40,250 --> 00:11:37,620
iron so it's not something that's alone

333
00:11:41,780 --> 00:11:40,260
in a vacuum and so I really like the

334
00:11:43,790 --> 00:11:41,790
idea yesterday of doing this takeaway

335
00:11:45,410 --> 00:11:43,800
message and really the takeaway message

336
00:11:46,610 --> 00:11:45,420
that I have and it's not just from this

337
00:11:48,949 --> 00:11:46,620
site but it's also looking at things

338
00:11:50,750 --> 00:11:48,959

like the banded iron formations that are

339
00:11:52,340 --> 00:11:50,760
all over Australia and some of the other

340
00:11:53,810 --> 00:11:52,350
interesting chemistry of these VMS

341
00:11:56,840 --> 00:11:53,820
systems not just in Australia but also

342
00:11:58,819 --> 00:11:56,850
in Canada it's increasingly looking like

343
00:12:02,000 --> 00:11:58,829
the archaean ocean chemistry at least in

344
00:12:04,639 --> 00:12:02,010
the redox element state is actually a

345
00:12:07,610 --> 00:12:04,649
lot like the modern ocean that at least

346
00:12:09,440 --> 00:12:07,620
the rise of oxygen as we know it might

347
00:12:11,990 --> 00:12:09,450
not have happened at 2.4 there obviously

348
00:12:14,090 --> 00:12:12,000
was a rise of oxygen but we need to do a

349
00:12:16,370 --> 00:12:14,100
little bit more fine-tuning as to

350
00:12:19,519 --> 00:12:16,380
exactly when it was and can we make a

351
00:12:21,290 --> 00:12:19,529
cyst can we choose a date that includes

352
00:12:23,510 --> 00:12:21,300
a lot of the geologic evidence that kind

353
00:12:33,319 --> 00:12:23,520
of stands as a major impediment to

354
00:12:48,790 --> 00:12:33,329
putting it at 2.4 thank you nicely done

355
00:12:56,140 --> 00:12:55,040
right so back urk basin basalt the

356
00:12:58,460 --> 00:12:56,150
reason we've chosen backward-facing

357
00:12:59,840 --> 00:12:58,470
there's actually been a lot of geologic

358
00:13:01,820 --> 00:12:59,850
work on this site because there are two

359
00:13:03,200 --> 00:13:01,830
economic grade and when people have

360
00:13:05,660 --> 00:13:03,210
actually looked at some of the petrology

361
00:13:07,580 --> 00:13:05,670
we see signals that are very very

362
00:13:10,160 --> 00:13:07,590
indicative of what we'd expect to see in

363
00:13:12,230 --> 00:13:10,170

a back arc setting in addition to that a

364
00:13:13,550 --> 00:13:12,240
lot of these VMS type formations

365
00:13:17,350 --> 00:13:13,560
particularly with the elemental

366
00:13:20,120 --> 00:13:17,360
concentrations of zinc lead and copper

367
00:13:21,400 --> 00:13:20,130
this VMS has like the the chemical

368
00:13:25,370 --> 00:13:21,410
footprint that we like to consider

369
00:13:31,370 --> 00:13:25,380
typical for a back arc setting I didn't

370
00:13:32,570 --> 00:13:31,380
recall was the second bit right so

371
00:13:35,090 --> 00:13:32,580
acidic solutions are going to be a

372
00:13:36,740 --> 00:13:35,100
byproduct of flowing actual the solution

373
00:13:40,490 --> 00:13:36,750
through the rock you're going to pick up

374
00:13:41,780 --> 00:13:40,500
a lot of either HCl or it's a couple

375
00:13:43,370 --> 00:13:41,790
different acids you're going to get from

376
00:13:44,890 --> 00:13:43,380
actually interacting with the water so

377
00:13:46,790 --> 00:13:44,900
you're starting with normal seawater

378
00:13:48,710 --> 00:13:46,800
turkey and is probably at least a log

379
00:13:50,300 --> 00:13:48,720
unit more acidic but it's actually just

380
00:13:51,950 --> 00:13:50,310
reactions with that surrounding ground

381
00:13:59,300 --> 00:13:51,960
through that rock that's actually

382
00:14:03,200 --> 00:13:59,310
generating an acidic solution so people

383
00:14:06,110 --> 00:14:03,210
typically interpret the isotope record

384
00:14:08,780 --> 00:14:06,120
from the archaean as there is

385
00:14:11,360 --> 00:14:08,790
insufficient marine sulfate for there to

386
00:14:12,980 --> 00:14:11,370
be ice topic fractionation by microbes

387
00:14:15,590 --> 00:14:12,990
but you're saying the concentrations

388
00:14:17,450 --> 00:14:15,600

were sufficient for that fractionation

389
00:14:18,890 --> 00:14:17,460
despite the fact the ice topic evidence

390
00:14:20,180 --> 00:14:18,900
doesn't support that sure you've heard

391
00:14:21,500 --> 00:14:20,190
this question before I'm just wondering

392
00:14:24,080 --> 00:14:21,510
how you reconcile that with your

393
00:14:27,770 --> 00:14:24,090
findings well so the big question is

394
00:14:30,500 --> 00:14:27,780
what do we what isotope record are we

395
00:14:32,420 --> 00:14:30,510
looking at so the bigger the bigger

396
00:14:35,240 --> 00:14:32,430
question we're looking at life is we're

397
00:14:37,130 --> 00:14:35,250
looking at the 34 sulfur fractionation

398
00:14:39,170 --> 00:14:37,140
and then is something that actually is

399
00:14:40,820 --> 00:14:39,180
interesting so if we actually look at

400
00:14:43,460 --> 00:14:40,830
these VMS systems or any of these

401
00:14:45,500 --> 00:14:43,470
systems if we're looking enough to

402
00:14:48,020 --> 00:14:45,510
actually have sulfate preserved as well

403
00:14:49,070 --> 00:14:48,030
as sulfide there is some fractionation

404
00:14:50,660 --> 00:14:49,080
between them so in the modern

405
00:14:54,050 --> 00:14:50,670
environment the fractionation between

406
00:14:55,350 --> 00:14:54,060
sulfate and sulfide is usually around 20

407
00:14:59,040 --> 00:14:55,360
per mil in a

408
00:15:00,720 --> 00:14:59,050
EMS system maybe 30 per mil in this case

409
00:15:03,480 --> 00:15:00,730
as we start moving towards the archaean

410
00:15:06,780 --> 00:15:03,490
you are correct it starts narrowing down

411
00:15:08,250 --> 00:15:06,790
and there is a lot of work that we're

412
00:15:10,889 --> 00:15:08,260
doing as to what is the component of

413
00:15:12,389 --> 00:15:10,899

that or what is the source of that it

414
00:15:14,940 --> 00:15:12,399
could be mixing you could have a larger

415
00:15:17,670 --> 00:15:14,950
component of actual just igneous

416
00:15:19,410 --> 00:15:17,680
sulfides leaching from rock there's a

417
00:15:21,840 --> 00:15:19,420
couple different things they could

418
00:15:23,100 --> 00:15:21,850
actually be helping form that people

419
00:15:24,720 --> 00:15:23,110
have done things like if you increase

420
00:15:27,720 --> 00:15:24,730
reaction rates you can also drive them

421
00:15:31,949 --> 00:15:27,730
together I'll admit that the sulfur

422
00:15:33,600 --> 00:15:31,959
isotope record is not my absolute area

423
00:15:35,759 --> 00:15:33,610
of expertise it's mine's more just the

424
00:15:37,290 --> 00:15:35,769
bulb chemistry but I can say that you're

425
00:15:38,910 --> 00:15:37,300
really really interested in the guy

426
00:15:40,800 --> 00:15:38,920
right behind you is doing a poster doing

427
00:15:44,009 --> 00:15:40,810
exactly what you're interested in in the

428
00:15:46,740 --> 00:15:44,019
archaean sulfur record all right