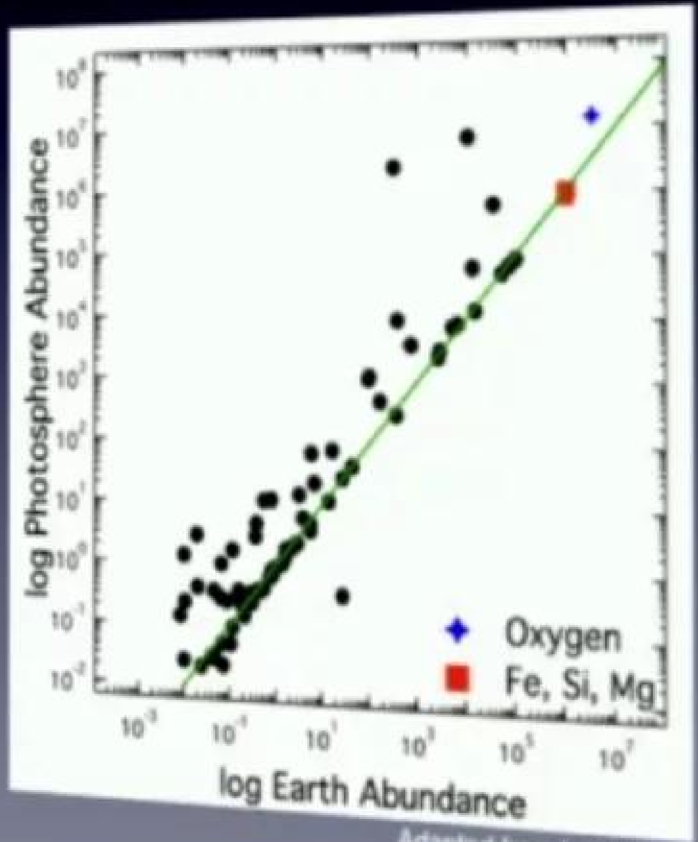
Earth-like Mineralogy?

- Adopt Solar abundances for refractory elements
- Earth not made of native elements, but oxidized minerals.
- 8x more Solar O than all cations combined



Adapted from Lodders, 2003; McDonough, 2003

1
00:00:14,810 --> 00:00:11,540
better yeah okay so this is sort of the

2
00:00:18,890 --> 00:00:14,820
canonical model of mass and radius and

3
00:00:20,990 --> 00:00:18,900
in this paper she wrote drew this blue

4
00:00:23,810 --> 00:00:21,000
line and said that is sort of the earth

5
00:00:25,340 --> 00:00:23,820
like line and a lot of these planets

6
00:00:27,019 --> 00:00:25,350
including earth and venus went through

7
00:00:29,630 --> 00:00:27,029
this line and then they sort of came up

8
00:00:31,279 --> 00:00:29,640
with his tautological saying that says

9
00:00:33,049 --> 00:00:31,289
planets inferred to be earth-like are

10
00:00:37,250 --> 00:00:33,059
indeed earth-like and that has a lot of

11
00:00:38,630 --> 00:00:37,260
implications so the question then we ask

12
00:00:39,950 --> 00:00:38,640
is well what does it really mean to be

13
00:00:41,990 --> 00:00:39,960

earth-like and then you can ask this

14
00:00:44,450 --> 00:00:42,000
even more existential question of is the

15
00:00:46,670 --> 00:00:44,460
earth even special if we can just fit

16
00:00:47,869 --> 00:00:46,680
all of these planets with this curve so

17
00:00:50,510 --> 00:00:47,879
I want to take a step back and actually

18
00:00:53,150 --> 00:00:50,520
look at the data we take for exoplanets

19
00:00:55,670 --> 00:00:53,160
so here is a different way to plot a

20
00:00:58,490 --> 00:00:55,680
mass radius model so this is data not a

21
00:01:00,950 --> 00:00:58,500
model this is radius on the x-axis and

22
00:01:03,410 --> 00:01:00,960
density and I've color coded the mass

23
00:01:05,539 --> 00:01:03,420
and you can see we've got some variation

24
00:01:08,359 --> 00:01:05,549
we've got some low density high radius

25
00:01:10,160 --> 00:01:08,369
and high density low radius and that may

26
00:01:12,590 --> 00:01:10,170
tell us something about the fraction of

27
00:01:14,600 --> 00:01:12,600
rock to core maybe something about gas

28
00:01:16,520 --> 00:01:14,610
envelopes it's very coarse in this model

29
00:01:19,460 --> 00:01:16,530
terrestrial planets are right here earth

30
00:01:20,870 --> 00:01:19,470
Venus mercury and Mars we also have

31
00:01:23,060 --> 00:01:20,880
another data set that is sometimes

32
00:01:25,700 --> 00:01:23,070
overlooked which is the actual

33
00:01:28,160 --> 00:01:25,710
composition of the host stars so here is

34
00:01:31,340 --> 00:01:28,170
a about a thousand stars from a sample

35
00:01:32,870 --> 00:01:31,350
of F G and K stars my flooded magnesium

36
00:01:36,020 --> 00:01:32,880
silicon versus iron silicon these are

37
00:01:38,960 --> 00:01:36,030
sort of terrestrial planet ratios the

38
00:01:41,300 --> 00:01:38,970

Sun is in blue red have observed planets

39
00:01:43,490 --> 00:01:41,310
we can see some spread and magnesium to

40
00:01:44,780 --> 00:01:43,500
silicon and some spread an iron to

41
00:01:46,850 --> 00:01:44,790
silicon and maybe this tells us

42
00:01:48,080 --> 00:01:46,860
something about the core size if you

43
00:01:50,240 --> 00:01:48,090
have a bigger core you should have more

44
00:01:53,090 --> 00:01:50,250
iron relatives of silicon and magnesium

45
00:01:54,800 --> 00:01:53,100
silicon is really the measure of what a

46
00:01:58,219 --> 00:01:54,810
planetary mantle should be made of

47
00:02:00,319 --> 00:01:58,229
particularly at mineralogy so really the

48
00:02:02,240 --> 00:02:00,329
focus of my PhD which I just wrapped up

49
00:02:04,069 --> 00:02:02,250
earlier this year was trying to connect

50
00:02:06,170 --> 00:02:04,079
these two datasets can we talk about how

51
00:02:08,809 --> 00:02:06,180
connecting the stellar data with the

52
00:02:11,750 --> 00:02:08,819
planetary mass radius data so to do that

53
00:02:13,580 --> 00:02:11,760
I want to then think about earth-like

54
00:02:14,869 --> 00:02:13,590
planets and i want to say okay well

55
00:02:16,940 --> 00:02:14,879
we have this earth like model can we

56
00:02:19,520 --> 00:02:16,950
even fit the earth to an earthlike model

57
00:02:21,050 --> 00:02:19,530
so if we're going to be extrapolating up

58
00:02:23,449 --> 00:02:21,060
to 5 earth masses let's make sure we get

59
00:02:25,250 --> 00:02:23,459
the earth rate so I I'm going to put

60
00:02:28,759 --> 00:02:25,260
this in mass and Composition space

61
00:02:30,289 --> 00:02:28,769
because connecting stars and planets and

62
00:02:33,110 --> 00:02:30,299
here's the earth I was silicon to iron

63
00:02:35,990 --> 00:02:33,120

ratio of 1 and 1 earth-mass ignore that

64
00:02:38,809 --> 00:02:36,000
blue line for now but if we were to see

65
00:02:39,890 --> 00:02:38,819
the earth what we would observe the

66
00:02:41,420 --> 00:02:39,900
earth we wouldn't be able to take it

67
00:02:43,520 --> 00:02:41,430
spectra we would have to take the sun's

68
00:02:44,869 --> 00:02:43,530
so the Sun has a slightly higher silicon

69
00:02:47,270 --> 00:02:44,879
iron ratio so we're just going to look

70
00:02:48,259 --> 00:02:47,280
at the Sun for now and this is the

71
00:02:50,870 --> 00:02:48,269
planet we're going to model we're going

72
00:02:52,160 --> 00:02:50,880
to model a one earth radius planet and

73
00:02:53,240 --> 00:02:52,170
so this is where you should pay

74
00:02:54,650 --> 00:02:53,250
attention in the blue one if you

75
00:02:56,420 --> 00:02:54,660
actually modeled a one earth radius

76
00:02:58,009 --> 00:02:56,430
planet using what we know about the

77
00:02:59,360 --> 00:02:58,019
earth as earth scientist you

78
00:03:02,839 --> 00:02:59,370
overestimate the mass of the Earth by

79
00:03:04,759 --> 00:03:02,849
about thirteen percent so that Earth

80
00:03:06,530 --> 00:03:04,769
model that canonical earth model is

81
00:03:08,780 --> 00:03:06,540
wrong and I can tell you some reasons

82
00:03:10,640 --> 00:03:08,790
why so one thing is they don't have an

83
00:03:13,130 --> 00:03:10,650
upper mantle in their model that seems

84
00:03:14,180 --> 00:03:13,140
obvious they just basically extrapolate

85
00:03:16,550 --> 00:03:14,190
bridgeman aight all the way up to the

86
00:03:18,830 --> 00:03:16,560
surface and they use a solid iron core

87
00:03:20,539 --> 00:03:18,840
whereas we know for the most part the

88
00:03:22,400 --> 00:03:20,549

core is liquid and we should expect

89
00:03:23,930 --> 00:03:22,410
liquid iron cores on most terrestrial

90
00:03:26,330 --> 00:03:23,940
planets just if you look at the phase

91
00:03:29,360 --> 00:03:26,340
diagram of iron terrestrial earth-sized

92
00:03:30,949 --> 00:03:29,370
planets and up and will keep the

93
00:03:34,309 --> 00:03:30,959
magnesium silicon ratio of the mantle at

94
00:03:36,620 --> 00:03:34,319
one that just makes easy so if you run

95
00:03:38,000 --> 00:03:36,630
this model my model you actually still

96
00:03:40,160 --> 00:03:38,010
overestimate the mass of the Earth by

97
00:03:42,379 --> 00:03:40,170
about five percent but that's good

98
00:03:44,720 --> 00:03:42,389
because we also were adding details to

99
00:03:47,330 --> 00:03:44,730
the spherical cow model I'll skip that

100
00:03:49,039 --> 00:03:47,340
so one thing that makes a difference in

101
00:03:50,809 --> 00:03:49,049
the Earth's mass is that the core is not

102
00:03:52,190 --> 00:03:50,819
pure iron it has some amount of light

103
00:03:54,050 --> 00:03:52,200
elements in it and you can choose your

104
00:03:56,059 --> 00:03:54,060
favorite light element so carbon and

105
00:03:57,559 --> 00:03:56,069
oxygen will definitely change the mass

106
00:03:59,750 --> 00:03:57,569
of the core but it does not change the

107
00:04:02,599 --> 00:03:59,760
silicon to iron ratio that much sulfur

108
00:04:03,979 --> 00:04:02,609
has a bigger effect silicon has a very

109
00:04:05,809 --> 00:04:03,989
large effect because it's in the

110
00:04:08,180 --> 00:04:05,819
numerator and somewhat in the

111
00:04:09,680 --> 00:04:08,190
denominator but you can see that we can

112
00:04:11,720 --> 00:04:09,690
change the mass the planet as well as

113
00:04:14,930 --> 00:04:11,730

it's silicon iron ore are inferred

114
00:04:16,610 --> 00:04:14,940
silicon to iron ratio and the other

115
00:04:18,259 --> 00:04:16,620
thing we can also you can choose sort of

116
00:04:19,759 --> 00:04:18,269
an optimum from mineral physics of what

117
00:04:21,440 --> 00:04:19,769
we think the Earth's core is like so

118
00:04:23,750 --> 00:04:21,450
let's benchmark to the earth and sort of

119
00:04:25,760 --> 00:04:23,760
compare across so this is some amount of

120
00:04:27,320 --> 00:04:25,770
silicon and oxygen we can also change

121
00:04:28,610 --> 00:04:27,330
the magnesium to silicon

122
00:04:30,170 --> 00:04:28,620
issue of the mantle and see how that

123
00:04:31,550 --> 00:04:30,180
changes our silicon to iron ratio and

124
00:04:33,800 --> 00:04:31,560
the mass and really from this you can

125
00:04:36,379 --> 00:04:33,810
see core density changes has a large

126
00:04:38,390 --> 00:04:36,389
effect on silicon to iron ore and mass

127
00:04:40,700 --> 00:04:38,400
whereas changing our the magnesium

128
00:04:42,649 --> 00:04:40,710
silicon ratio of the mantle has a small

129
00:04:44,420 --> 00:04:42,659
effect on mass but a large effect or a

130
00:04:46,399 --> 00:04:44,430
somewhat effect on silicon and iron and

131
00:04:49,209 --> 00:04:46,409
there's the Sun which falls nicely in my

132
00:04:52,100 --> 00:04:49,219
model and if you take an earth model

133
00:04:54,679 --> 00:04:52,110
which is sort of by this green box some

134
00:04:57,170 --> 00:04:54,689
core density between about five and ten

135
00:04:58,670 --> 00:04:57,180
percent less than iron and a magnesium

136
00:05:00,890 --> 00:04:58,680
silicon ratio of the mantle which you

137
00:05:02,390 --> 00:05:00,900
can look at the mantle xenoliths and

138
00:05:03,980 --> 00:05:02,400

maybe get an idea of the mantles

139
00:05:06,379 --> 00:05:03,990
magnesium silicon ratio falls in that

140
00:05:08,270 --> 00:05:06,389
green box so in this plot I've reverse

141
00:05:10,670 --> 00:05:08,280
engineered the earth using the Sun

142
00:05:12,649 --> 00:05:10,680
that's pretty cool so in this sense for

143
00:05:15,110 --> 00:05:12,659
my barely course order of magnitude

144
00:05:16,159 --> 00:05:15,120
model I've the Sun is a good proxy for

145
00:05:20,149 --> 00:05:16,169
the earth so if you're going to tweet

146
00:05:22,189 --> 00:05:20,159
that's we should so if you can expand

147
00:05:23,689 --> 00:05:22,199
that we earth is great but let's talk

148
00:05:26,300 --> 00:05:23,699
about earth-like planets across the mass

149
00:05:28,550 --> 00:05:26,310
radius spectrum so here is radius versus

150
00:05:29,600 --> 00:05:28,560
silicon to iron in astronomy units and

151
00:05:32,540 --> 00:05:29,610
I'll tell you why it's an astronomer

152
00:05:34,369 --> 00:05:32,550
unit in just a second and what this says

153
00:05:36,740 --> 00:05:34,379
is if you have radio or if you have

154
00:05:39,050 --> 00:05:36,750
planetary radius which is what you would

155
00:05:40,219 --> 00:05:39,060
get from a transit method you have to

156
00:05:43,790 --> 00:05:40,229
actually follow up to get a mass

157
00:05:45,350 --> 00:05:43,800
measurement while you're there you might

158
00:05:47,029 --> 00:05:45,360
as well measure the stellar composition

159
00:05:48,800 --> 00:05:47,039
and get a silicon to iron ratio and from

160
00:05:51,230 --> 00:05:48,810
that you can actually oh these contours

161
00:05:53,899 --> 00:05:51,240
are contours of constant mass so you can

162
00:05:55,730 --> 00:05:53,909
run across say oh well there's my planet

163
00:05:58,279 --> 00:05:55,740

and then this earth like range is just

164
00:06:01,600 --> 00:05:58,289
the core size that is bound by the Sun

165
00:06:04,879 --> 00:06:01,610
and the earth true silicon iron ratio so

166
00:06:07,550 --> 00:06:04,889
next up is well is that a true

167
00:06:09,290 --> 00:06:07,560
assumption is the sun's composition a

168
00:06:11,300 --> 00:06:09,300
good proxy for the earth from a chemical

169
00:06:15,170 --> 00:06:11,310
perspective or from a Cosmo chemist

170
00:06:16,820 --> 00:06:15,180
perspective so this is how I defend that

171
00:06:18,980 --> 00:06:16,830
so this is the photospheric abundance

172
00:06:21,439 --> 00:06:18,990
versus the c1 chondrites which is one

173
00:06:24,589 --> 00:06:21,449
earth model for what the earth might be

174
00:06:27,019 --> 00:06:24,599
made of so iron and silicon magnesium

175
00:06:28,879 --> 00:06:27,029
are all elements that are refractory and

176
00:06:31,249 --> 00:06:28,889
what that means is if you're if you have

177
00:06:33,740 --> 00:06:31,259
a gas these will condense first at very

178
00:06:35,449 --> 00:06:33,750
high temperatures so in this one to one

179
00:06:37,370 --> 00:06:35,459
line which is in green you can see those

180
00:06:39,589 --> 00:06:37,380
three elements following falling nicely

181
00:06:40,600 --> 00:06:39,599
on it oxygen is a little bit above and

182
00:06:42,490 --> 00:06:40,610
I'll talk about that

183
00:06:44,529 --> 00:06:42,500
second so you can then make the next

184
00:06:46,570 --> 00:06:44,539
step and look at the actual earth

185
00:06:48,670 --> 00:06:46,580
abundance for some earth compositional

186
00:06:50,439 --> 00:06:48,680
model versus photosphere and again those

187
00:06:52,839 --> 00:06:50,449
are pretty close to that one to one line

188
00:06:55,510 --> 00:06:52,849

but oxygen is not and that's important

189
00:06:57,550 --> 00:06:55,520
because the earth is not made of just

190
00:07:00,399 --> 00:06:57,560
refractory metals they are oxidized

191
00:07:02,770 --> 00:07:00,409
species so if you were to use the sun's

192
00:07:04,899 --> 00:07:02,780
oxygen abundance you would actually over

193
00:07:07,360 --> 00:07:04,909
predict the total oxygen budget of the

194
00:07:09,339 --> 00:07:07,370
planet by a factor of eight or so which

195
00:07:11,499 --> 00:07:09,349
means you would oxidize everything there

196
00:07:14,050 --> 00:07:11,509
would be no core and that's not the

197
00:07:17,320 --> 00:07:14,060
planet we live on and that kind of makes

198
00:07:19,779 --> 00:07:17,330
sense oxygen is a volatile element you

199
00:07:21,760 --> 00:07:19,789
would think of so we need to make some

200
00:07:23,260 --> 00:07:21,770
correction for on the oxygen its to

201
00:07:25,510 --> 00:07:23,270
basically turn it into what I call

202
00:07:27,779 --> 00:07:25,520
refractory oxygen to say this is the

203
00:07:30,100 --> 00:07:27,789
oxygen abundance that or some

204
00:07:31,809 --> 00:07:30,110
approximation of the oxygen abundance of

205
00:07:33,249 --> 00:07:31,819
a planet and I'm always sticking with

206
00:07:35,439 --> 00:07:33,259
the earth because I want to benchmark to

207
00:07:37,629 --> 00:07:35,449
the earth and then expand that model

208
00:07:40,119 --> 00:07:37,639
outwards just to make actual comparisons

209
00:07:42,399 --> 00:07:40,129
across the exoplanet data set so to do

210
00:07:45,969 --> 00:07:42,409
that you need to create the phase

211
00:07:47,409 --> 00:07:45,979
diagram for a solar gas and this is a

212
00:07:49,450 --> 00:07:47,419
you may have heard of it also called

213
00:07:51,640 --> 00:07:49,460

condensation sequences so you would take

214
00:07:53,890 --> 00:07:51,650
a very hot gas and let it cool down and

215
00:07:55,659 --> 00:07:53,900
see which solids form first so I show

216
00:07:58,990 --> 00:07:55,669
aluminum even though aluminum is a dinky

217
00:08:00,399 --> 00:07:59,000
element with regards to planets it's the

218
00:08:01,959 --> 00:08:00,409
it's the coolest phase diagram because

219
00:08:03,519 --> 00:08:01,969
you can see everything that goes on so

220
00:08:05,439 --> 00:08:03,529
you start up really high we have mono

221
00:08:07,689 --> 00:08:05,449
atomic gases then you start forming more

222
00:08:10,179 --> 00:08:07,699
complex things like aluminum gas and a

223
00:08:11,860 --> 00:08:10,189
LOH and then the solid start forming you

224
00:08:14,290 --> 00:08:11,870
get things like corundum a really

225
00:08:15,939 --> 00:08:14,300
refractory mineral but eventually it all

226
00:08:18,219 --> 00:08:15,949
settles down to things like an earth

227
00:08:20,740 --> 00:08:18,229
aight and but this inner thigh here says

228
00:08:22,959 --> 00:08:20,750
that for every aluminum atom i may form

229
00:08:24,610 --> 00:08:22,969
a planet with i carry eight moles of

230
00:08:27,129 --> 00:08:24,620
oxygen so then you can start playing

231
00:08:30,070 --> 00:08:27,139
stoichiometry games so here is probably

232
00:08:33,370 --> 00:08:30,080
which was surprising to me is not often

233
00:08:34,750 --> 00:08:33,380
thought of the oxygen phase diagram so

234
00:08:37,719 --> 00:08:34,760
here you start high and you get some

235
00:08:40,060 --> 00:08:37,729
these cais which are these dashed lines

236
00:08:42,370 --> 00:08:40,070
but then really things we think about

237
00:08:44,620 --> 00:08:42,380
form terrestrial planets forced to write

238
00:08:48,310 --> 00:08:44,630

enstatite are the main host of oxygen

239
00:08:52,269 --> 00:08:48,320
and total about 23% for this solar model

240
00:08:53,890 --> 00:08:52,279
fall into oxygen is refractory so that

241
00:08:55,780 --> 00:08:53,900
would be your sort of

242
00:08:59,200 --> 00:08:55,790
estimate of your oxygen budget with

243
00:09:01,930 --> 00:08:59,210
which to build planet which is my very

244
00:09:04,900 --> 00:09:01,940
simple super duper planet if you have

245
00:09:06,520 --> 00:09:04,910
those four elements and later two more

246
00:09:08,650 --> 00:09:06,530
but for the most part you can describe

247
00:09:10,510 --> 00:09:08,660
the earth really well in its structure

248
00:09:13,330 --> 00:09:10,520
in its mineralogy with those four

249
00:09:15,790 --> 00:09:13,340
elements for the bulk of the mantle and

250
00:09:17,590 --> 00:09:15,800
the upper mantle so let's look at it in

251
00:09:20,590 --> 00:09:17,600
a different way so this is the same

252
00:09:22,570 --> 00:09:20,600
thousand stars i showed earlier just on

253
00:09:25,240 --> 00:09:22,580
a ternary so here's iron magnesium and

254
00:09:27,040 --> 00:09:25,250
silicon the red are that is the same

255
00:09:29,290 --> 00:09:27,050
data set i showed earlier the black are

256
00:09:32,020 --> 00:09:29,300
the kepler stars and there's the Sun

257
00:09:34,270 --> 00:09:32,030
sort of right smack in the middle now so

258
00:09:37,000 --> 00:09:34,280
you can run you've now you've got iron

259
00:09:38,830 --> 00:09:37,010
magnesium silicon and oxygen you can

260
00:09:40,480 --> 00:09:38,840
calculate the weight percent of the core

261
00:09:43,780 --> 00:09:40,490
or the core mass percent which are these

262
00:09:45,250 --> 00:09:43,790
contours here so the Sun great falls

263
00:09:49,390 --> 00:09:45,260

exactly kind of where we expected

264
00:09:53,200 --> 00:09:49,400
between 30 and 35 mass percent of a core

265
00:09:57,040 --> 00:09:53,210
the real answer is about 33 32 so good

266
00:09:58,780 --> 00:09:57,050
we've now shown or I we had to their

267
00:10:00,970 --> 00:09:58,790
stellar diversity and planet diversity

268
00:10:02,380 --> 00:10:00,980
are linked so why would I would predict

269
00:10:04,720 --> 00:10:02,390
that little black spot if it had a

270
00:10:07,720 --> 00:10:04,730
planet this probably has a very high

271
00:10:09,370 --> 00:10:07,730
core fraction as well mass fraction and

272
00:10:10,690 --> 00:10:09,380
there may be populations it's a little

273
00:10:12,640 --> 00:10:10,700
hard to see here but there's a bit of a

274
00:10:15,040 --> 00:10:12,650
lobe and then you've got sort of this

275
00:10:16,900 --> 00:10:15,050
spread what do those planets look like

276
00:10:19,360 --> 00:10:16,910
what's the true diversity so this is

277
00:10:21,610 --> 00:10:19,370
something where I am giving a talk at an

278
00:10:23,230 --> 00:10:21,620
astrobiology conference but I think of

279
00:10:24,940 --> 00:10:23,240
things in planetary diversity not

280
00:10:28,600 --> 00:10:24,950
planetary habitability I want to

281
00:10:30,190 --> 00:10:28,610
understand how likely are Earth's so

282
00:10:32,500 --> 00:10:30,200
that's because now I'm of course

283
00:10:34,030 --> 00:10:32,510
completely talk myself into a corner

284
00:10:36,460 --> 00:10:34,040
because I want to talk about

285
00:10:39,190 --> 00:10:36,470
habitability now so this is a really

286
00:10:42,100 --> 00:10:39,200
crummy picture of tectonics so if you

287
00:10:43,750 --> 00:10:42,110
shut off tectonics of course you it does

288
00:10:46,630 --> 00:10:43,760

a great job of regulating the atmosphere

289
00:10:48,400 --> 00:10:46,640
so you're pumping carbon in and this has

290
00:10:50,710 --> 00:10:48,410
of course heat problems for how your

291
00:10:52,450 --> 00:10:50,720
core crystallizes so one thing I'll talk

292
00:10:54,490 --> 00:10:52,460
about really quickly is one thing that

293
00:10:57,880 --> 00:10:54,500
controls tectonics which may control

294
00:11:00,070 --> 00:10:57,890
habitability is buoyancy of the plates

295
00:11:02,350 --> 00:11:00,080
so as a plate goes down it undergoes a

296
00:11:04,180 --> 00:11:02,360
phase transition it becomes a really

297
00:11:05,680 --> 00:11:04,190
terrible term negatively buoyant and

298
00:11:07,570 --> 00:11:05,690
keep sinking and it's one of the things

299
00:11:10,240 --> 00:11:07,580
that helps power plate tectonics

300
00:11:12,310 --> 00:11:10,250
it's also a purely chemical process well

301
00:11:14,830 --> 00:11:12,320
chemical and mineral physical property

302
00:11:16,900 --> 00:11:14,840
so i want to know within this sample

303
00:11:18,250 --> 00:11:16,910
which one of these which of these

304
00:11:20,950 --> 00:11:18,260
compositions are likely to produce

305
00:11:22,660 --> 00:11:20,960
planets that can undergo that phase

306
00:11:24,850 --> 00:11:22,670
transition and become successfully

307
00:11:26,920 --> 00:11:24,860
negatively buoyant and keep sinking so

308
00:11:29,020 --> 00:11:26,930
this is sort of big data planetary

309
00:11:31,540 --> 00:11:29,030
science and just asking the question how

310
00:11:33,190 --> 00:11:31,550
common is our negatively buoyant plates

311
00:11:35,020 --> 00:11:33,200
I'm not saying whether plate tectonics

312
00:11:38,230 --> 00:11:35,030
is occurring I'm just saying if it did

313
00:11:41,230 --> 00:11:38,240

what what is the likelihood so we need

314
00:11:43,450 --> 00:11:41,240
to melt everything and basically get an

315
00:11:46,600 --> 00:11:43,460
idea of what the basaltic crust is and

316
00:11:49,390 --> 00:11:46,610
then make the phase diagrams so here is

317
00:11:52,300 --> 00:11:49,400
your basalt phase diagram this is for

318
00:11:54,250 --> 00:11:52,310
our earth model again benchmarking to

319
00:11:57,180 --> 00:11:54,260
the earth and here's your basalt you

320
00:11:59,740 --> 00:11:57,190
integrate the differences in density

321
00:12:02,530 --> 00:11:59,750
down at whatever depth you want and you

322
00:12:04,930 --> 00:12:02,540
can calculate a buoyancy force so here

323
00:12:07,150 --> 00:12:04,940
is and these are preliminary results

324
00:12:09,490 --> 00:12:07,160
they're almost done the papers written

325
00:12:11,650 --> 00:12:09,500
we just need to finagle so this is

326
00:12:13,390 --> 00:12:11,660
magnesium silicon vs. net buoyancy force

327
00:12:15,090 --> 00:12:13,400
running through a lot of chemistry that

328
00:12:17,620 --> 00:12:15,100
if you're interested I can talk about

329
00:12:20,200 --> 00:12:17,630
and I've made a line for the model earth

330
00:12:22,630 --> 00:12:20,210
and only about 5% of that total thousand

331
00:12:24,610 --> 00:12:22,640
star sample actually works to create

332
00:12:26,830 --> 00:12:24,620
negatively buoyant plates so I'll leave

333
00:12:30,010 --> 00:12:26,840
it here my real point which I've

334
00:12:32,170 --> 00:12:30,020
underlined here is that earth-like does

335
00:12:33,580 --> 00:12:32,180
not mean compositionally similar it may

336
00:12:36,100 --> 00:12:33,590
not even mean the atmosphere is the same

337
00:12:38,170 --> 00:12:36,110
it behaves like the earth because

338
00:12:40,330 --> 00:12:38,180

tectonics dynamics are really what's

339
00:12:41,950 --> 00:12:40,340
powering all of us and we all need to

340
00:12:48,340 --> 00:12:41,960
work together to solve the problem so

341
00:12:57,469 --> 00:12:54,650
alright question already thank you

342
00:13:00,710 --> 00:12:57,479
regarding up plate tectonics and also a

343
00:13:03,710 --> 00:13:00,720
buoyancy of mental material how do you

344
00:13:05,269 --> 00:13:03,720
rectify similar chemical composition

345
00:13:11,989 --> 00:13:05,279
between Earth and Venus and and

346
00:13:14,629 --> 00:13:11,999
excellent question so this I I Venus is

347
00:13:16,549 --> 00:13:14,639
always gonna dog this question if the

348
00:13:18,229 --> 00:13:16,559
sun's composition is similar then Venus

349
00:13:20,359 --> 00:13:18,239
and Earth should be exactly the same so

350
00:13:22,879 --> 00:13:20,369
right now we're working on getting

351
00:13:25,219 --> 00:13:22,889
mixing to understand maybe something

352
00:13:26,779 --> 00:13:25,229
Venus or earth form slightly differently

353
00:13:28,699 --> 00:13:26,789
or that we're not taking into account

354
00:13:31,639 --> 00:13:28,709
actual discs mixings or something like

355
00:13:33,349 --> 00:13:31,649
that and then if we see that that

356
00:13:36,229 --> 00:13:33,359
doesn't work we're going to will add

357
00:13:40,369 --> 00:13:36,239
extra details of history you know what

358
00:13:43,519 --> 00:13:40,379
happened to make and sort of it's sort

359
00:13:45,049 --> 00:13:43,529
of its constraining Earth and Venus from

360
00:13:47,150 --> 00:13:45,059
the outside like what doesn't work

361
00:13:48,769 --> 00:13:47,160
versus what did work and we'll add

362
00:13:51,710 --> 00:13:48,779
details as we go but I am really

363
00:13:53,419 --> 00:13:51,720

interested in Venus and I think thinking

364
00:13:54,979 --> 00:13:53,429
of Earth and Venus as sort of the ideal

365
00:13:57,079 --> 00:13:54,989
and not ideal exoplanet and

366
00:13:59,509 --> 00:13:57,089
understanding the differences is a

367
00:14:03,679 --> 00:13:59,519
really profound way of understanding all

368
00:14:10,000 --> 00:14:03,689
of X of planetary science Thank You

369
00:14:15,110 --> 00:14:12,920
yeah so is there any worried that the

370
00:14:17,240 --> 00:14:15,120
dynamics like how you form these planets

371
00:14:19,190 --> 00:14:17,250
sort of obscures the link between

372
00:14:20,660 --> 00:14:19,200
Stemler composition and planetary

373
00:14:22,790 --> 00:14:20,670
encompasses yeah so right now I'm

374
00:14:26,300 --> 00:14:22,800
working I just started my postdoc

375
00:14:27,920 --> 00:14:26,310
working on integrating so the the

376
00:14:30,380 --> 00:14:27,930
condensation sequence code I've written

377
00:14:33,740 --> 00:14:30,390
with mixing models to sort of get an

378
00:14:39,800 --> 00:14:33,750
idea of feeding zones so one of the

379
00:14:41,720 --> 00:14:39,810
things in this this plot here is I show

380
00:14:43,970 --> 00:14:41,730
I bound by the earth and the Sun but

381
00:14:45,829 --> 00:14:43,980
Venus doesn't actually work unless you

382
00:14:48,500 --> 00:14:45,839
use a slightly higher magnesium to

383
00:14:51,850 --> 00:14:48,510
Silicon number for the for the mantle

384
00:14:54,680 --> 00:14:51,860
and that's interesting because in the

385
00:14:58,310 --> 00:14:54,690
oxygen phase diagram you get something

386
00:15:01,070 --> 00:14:58,320
of mg mg / SI of two condensing before

387
00:15:03,200 --> 00:15:01,080
mgs I of one so if you preferentially

388
00:15:05,930 --> 00:15:03,210

mix from higher temperature closer to

389
00:15:08,450 --> 00:15:05,940
your star stuff you might expect high

390
00:15:10,910 --> 00:15:08,460
mgs I so that's worth figuring out what

391
00:15:13,010 --> 00:15:10,920
up adding a dynamical component saying

392
00:15:14,990 --> 00:15:13,020
this is where it fed from here's what

393
00:15:16,490 --> 00:15:15,000
the stuff the chemistry of the stuff

394
00:15:18,380 --> 00:15:16,500
that formed from now run the

395
00:15:21,440 --> 00:15:18,390
stoichiometry and figure things out so