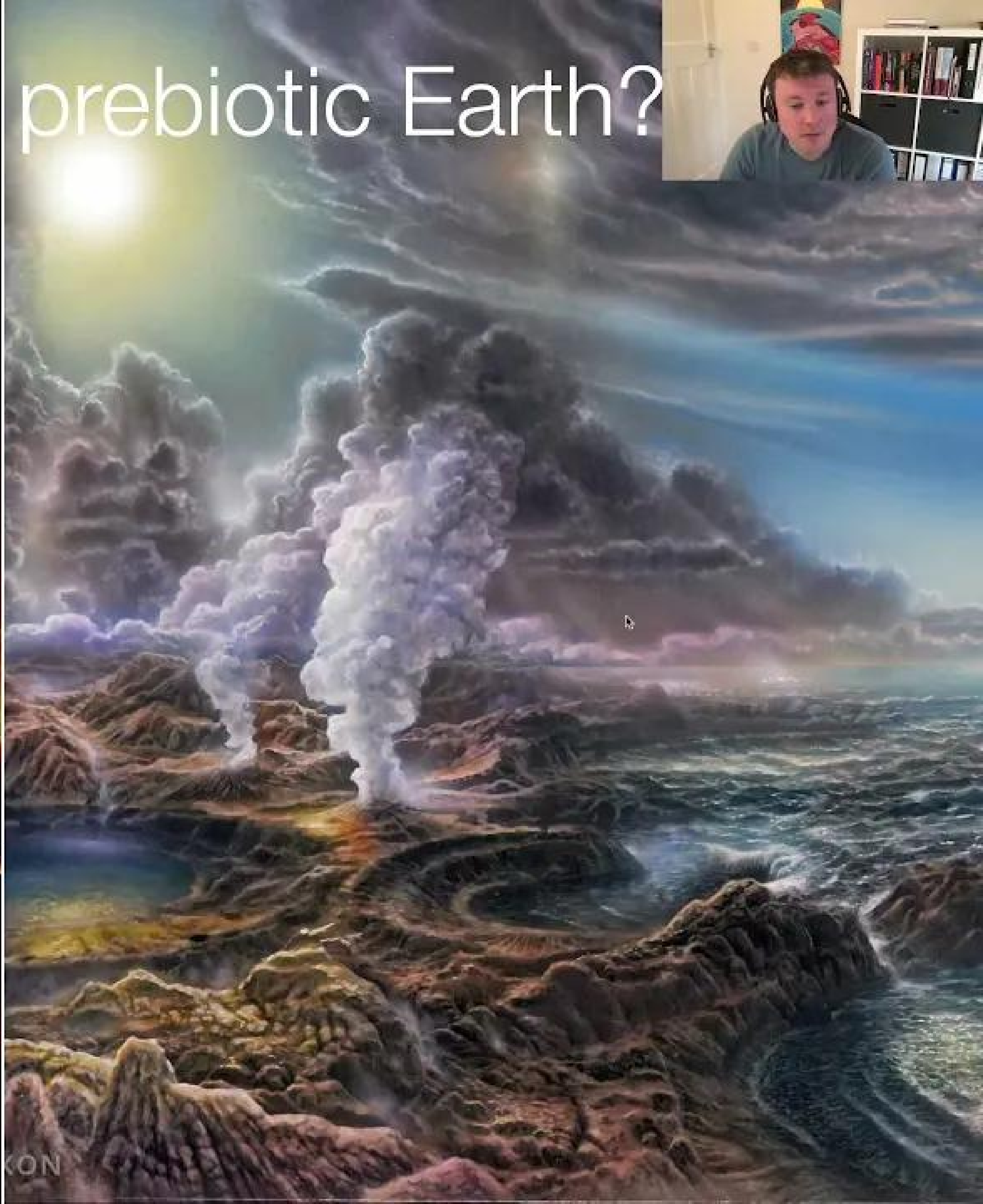
What kind of world was the prebiotic Earth?



1
00:00:05,110 --> 00:00:03,350
hello everyone

2
00:00:06,389 --> 00:00:05,120
i'm tim liechtenberg from oxford and i

3
00:00:07,990 --> 00:00:06,399
work on the formation and early

4
00:00:09,430 --> 00:00:08,000
evolution of terrestrial planets in the

5
00:00:11,110 --> 00:00:09,440
atmospheres

6
00:00:13,589 --> 00:00:11,120
my principal goal is it to better

7
00:00:15,430 --> 00:00:13,599
understand the early formation and

8
00:00:17,269 --> 00:00:15,440
evolution phase of terrestrial planets

9
00:00:19,349 --> 00:00:17,279
in order to infer something about the

10
00:00:21,990 --> 00:00:19,359
planetary environment of the haitian

11
00:00:23,109 --> 00:00:22,000
earth with the ultimate goal of better

12
00:00:26,230 --> 00:00:23,119
understand you know

13
00:00:27,109 --> 00:00:26,240

what what was the environment that

14
00:00:30,390 --> 00:00:27,119
enabled

15
00:00:31,589 --> 00:00:30,400
the origin of life on earth um but i

16
00:00:33,750 --> 00:00:31,599
think we should look out

17
00:00:34,790 --> 00:00:33,760
in order to infer something about

18
00:00:37,590 --> 00:00:34,800
ourselves

19
00:00:37,990 --> 00:00:37,600
why is that so what you see over here

20
00:00:41,110 --> 00:00:38,000
are

21
00:00:43,110 --> 00:00:41,120
scenarios of the hadi nurse

22
00:00:44,790 --> 00:00:43,120
with uh hiding earth which was a very

23
00:00:47,350 --> 00:00:44,800
defining phase

24
00:00:48,470 --> 00:00:47,360
on earth and we have no geological

25
00:00:51,670 --> 00:00:48,480
record of this

26
00:00:53,830 --> 00:00:51,680
and there's basically 500 million years

27
00:00:55,830 --> 00:00:53,840
directly after transformation that are

28
00:00:59,110 --> 00:00:55,840
completely gone and vanish

29
00:01:00,549 --> 00:00:59,120
from managed from our site um

30
00:01:02,389 --> 00:01:00,559
after the apollo mission we had this

31
00:01:03,349 --> 00:01:02,399
picture of the hedin earth very hellish

32
00:01:04,469 --> 00:01:03,359
you know frequent meteoritic

33
00:01:07,510 --> 00:01:04,479
bombardments

34
00:01:07,910 --> 00:01:07,520
uh constant volcanic outpourings but

35
00:01:09,670 --> 00:01:07,920
since

36
00:01:11,350 --> 00:01:09,680
evidence for liquid water the earth's

37
00:01:13,510 --> 00:01:11,360
surface emerged

38
00:01:15,030 --> 00:01:13,520

about very rapidly after the moon

39
00:01:18,149 --> 00:01:15,040
forming impact in fact

40
00:01:20,390 --> 00:01:18,159
the picture is you know in question and

41
00:01:21,670 --> 00:01:20,400
but still we have very little that can

42
00:01:24,469 --> 00:01:21,680
help us from a geo

43
00:01:25,510 --> 00:01:24,479
geology point of view and so what we're

44
00:01:28,710 --> 00:01:25,520
aiming to do

45
00:01:30,630 --> 00:01:28,720
is to actually look to other planetary

46
00:01:32,069 --> 00:01:30,640
systems that are still currently in that

47
00:01:34,789 --> 00:01:32,079
phase and that are young

48
00:01:36,390 --> 00:01:34,799
and that um that can inform us about how

49
00:01:37,590 --> 00:01:36,400
terrestrial planets at that stage of

50
00:01:40,230 --> 00:01:37,600
evolution evolve

51
00:01:41,830 --> 00:01:40,240
and how they look like and principal

52
00:01:43,270 --> 00:01:41,840
questions are of course for instance the

53
00:01:44,149 --> 00:01:43,280
composition of the atmosphere and the

54
00:01:45,990 --> 00:01:44,159
interior

55
00:01:48,069 --> 00:01:46,000
that can help us to inform the

56
00:01:48,870 --> 00:01:48,079
geochemistry of the surface at that

57
00:01:51,270 --> 00:01:48,880
stage

58
00:01:53,109 --> 00:01:51,280
why is that important so for instance

59
00:01:54,870 --> 00:01:53,119
here you see the interior the interior

60
00:01:57,190 --> 00:01:54,880
composition determines the amount of

61
00:01:59,190 --> 00:01:57,200
gases or the composition of the gases

62
00:02:01,109 --> 00:01:59,200
that is degassed and forms the

63
00:02:02,789 --> 00:02:01,119

atmosphere the atmosphere itself

64
00:02:04,550 --> 00:02:02,799
is also of course very important because

65
00:02:05,590 --> 00:02:04,560
it kind of sets the uv environment of

66
00:02:07,990 --> 00:02:05,600
the surface

67
00:02:09,749 --> 00:02:08,000
and it gets influenced by the radiation

68
00:02:12,390 --> 00:02:09,759
environment from the star

69
00:02:14,070 --> 00:02:12,400
and it can directly react to changes but

70
00:02:15,750 --> 00:02:14,080
for instance

71
00:02:17,670 --> 00:02:15,760
from bombardment yeah commentary or

72
00:02:20,949 --> 00:02:17,680
meteoritic bombardment

73
00:02:23,030 --> 00:02:20,959
now those two things together

74
00:02:24,869 --> 00:02:23,040
make up the geochemistry of the surface

75
00:02:26,229 --> 00:02:24,879
this directly affects the feedstocks

76
00:02:28,309 --> 00:02:26,239
that are available for prebiotic

77
00:02:32,229 --> 00:02:28,319
chemistry

78
00:02:35,430 --> 00:02:32,239
so the combining the combining link here

79
00:02:37,190 --> 00:02:35,440
is the redox state and all of them are

80
00:02:39,430 --> 00:02:37,200
set and are affected and affect

81
00:02:40,070 --> 00:02:39,440
themselves the radius redox state of the

82
00:02:42,150 --> 00:02:40,080
mantle

83
00:02:43,589 --> 00:02:42,160
and the prebiotic chemical networks that

84
00:02:46,630 --> 00:02:43,599
can play out

85
00:02:48,070 --> 00:02:46,640
on a given planet at a given stage now

86
00:02:50,070 --> 00:02:48,080
what you see on that next slide is a

87
00:02:52,470 --> 00:02:50,080
sort of confusogram but

88
00:02:53,670 --> 00:02:52,480

it shows one envision possible pathway

89
00:02:55,350 --> 00:02:53,680
of how

90
00:02:56,710 --> 00:02:55,360
terrestrial rocky planets in general

91
00:02:59,110 --> 00:02:56,720
acquire the atmospheres

92
00:03:00,470 --> 00:02:59,120
so this is time and this is the material

93
00:03:02,550 --> 00:03:00,480
and this is the atmosphere

94
00:03:04,229 --> 00:03:02,560
in the beginning i just thought that

95
00:03:05,190 --> 00:03:04,239
terrestrial rocky planets specifically

96
00:03:07,270 --> 00:03:05,200
larger ones

97
00:03:08,710 --> 00:03:07,280
still have hydrogen-rich atmospheres

98
00:03:09,910 --> 00:03:08,720
that are directly sourced from the port

99
00:03:11,589 --> 00:03:09,920
planetary disk

100
00:03:13,509 --> 00:03:11,599
the mantle is molten because from its

101
00:03:16,149 --> 00:03:13,519
secretionary heat but then solidifies

102
00:03:17,990 --> 00:03:16,159
over this over some time the primary

103
00:03:19,750 --> 00:03:18,000
atmosphere is lost due to escape

104
00:03:21,670 --> 00:03:19,760
and then it's replenished from volcanic

105
00:03:23,190 --> 00:03:21,680
outgassing that is why the composition

106
00:03:25,509 --> 00:03:23,200
of the interior is so important

107
00:03:26,710 --> 00:03:25,519
because it sets the composition of the

108
00:03:28,309 --> 00:03:26,720
gases that are released to the

109
00:03:31,430 --> 00:03:28,319
atmosphere

110
00:03:32,550 --> 00:03:31,440
now this story can be different

111
00:03:33,910 --> 00:03:32,560
depending on the composition of the

112
00:03:35,910 --> 00:03:33,920
planet and therefore

113
00:03:39,030 --> 00:03:35,920

depending on the specific accretion path

114
00:03:41,110 --> 00:03:39,040
of the planet itself

115
00:03:42,390 --> 00:03:41,120
and this changes very dramatically how

116
00:03:44,470 --> 00:03:42,400
these planets evolve

117
00:03:45,990 --> 00:03:44,480
during the earliest phase so here for

118
00:03:47,750 --> 00:03:46,000
instance you see the cooling from magma

119
00:03:49,670 --> 00:03:47,760
ocean to a habitable planet this is

120
00:03:51,270 --> 00:03:49,680
surface temperature this is cooling of

121
00:03:52,390 --> 00:03:51,280
the planet by heat loss through the

122
00:03:55,270 --> 00:03:52,400
atmosphere

123
00:03:56,630 --> 00:03:55,280
and depending on the primary composition

124
00:03:59,270 --> 00:03:56,640
of the atmosphere for instance if it's

125
00:04:01,030 --> 00:03:59,280
h2o dominated o2 dominated ch4 dominated

126
00:04:03,350 --> 00:04:01,040
to h2 dominated

127
00:04:05,110 --> 00:04:03,360
the heat loss is dramatically different

128
00:04:07,509 --> 00:04:05,120
several orders of magnitude

129
00:04:08,710 --> 00:04:07,519
this is very severe consequences for the

130
00:04:10,710 --> 00:04:08,720
surface environment

131
00:04:12,830 --> 00:04:10,720
for the geochemistry of the mantle and

132
00:04:14,309 --> 00:04:12,840
for the composition of the long left

133
00:04:17,749 --> 00:04:14,319
atmosphere

134
00:04:20,469 --> 00:04:17,759
now um that's why we develop

135
00:04:20,870 --> 00:04:20,479
computational models and actually can

136
00:04:23,270 --> 00:04:20,880
can

137
00:04:24,390 --> 00:04:23,280
quantify the differences between those

138
00:04:25,749 --> 00:04:24,400

scenarios

139
00:04:27,590 --> 00:04:25,759
this is what you see here on the right

140
00:04:28,950 --> 00:04:27,600
you see like basically the evolution of

141
00:04:31,670 --> 00:04:28,960
a magma ocean planet

142
00:04:34,710 --> 00:04:31,680
in this case an earth-sized one for an

143
00:04:36,629 --> 00:04:34,720
h2 an h2o dominated atmosphere

144
00:04:38,070 --> 00:04:36,639
so this is temperature in k depths and

145
00:04:39,909 --> 00:04:38,080
mantle height and atmosphere

146
00:04:42,070 --> 00:04:39,919
and you see the difference and cooling

147
00:04:44,629 --> 00:04:42,080
behavior of an h2 and h2o1

148
00:04:45,189 --> 00:04:44,639
from 100 year to one mega year and you

149
00:04:46,710 --> 00:04:45,199
see that

150
00:04:48,469 --> 00:04:46,720
after one mega year the surface

151
00:04:49,830 --> 00:04:48,479
temperature is strongly different very

152
00:04:52,230 --> 00:04:49,840
very starkly

153
00:04:53,749 --> 00:04:52,240
strongly differing and also this

154
00:04:54,469 --> 00:04:53,759
stratification of the atmosphere is

155
00:04:56,310 --> 00:04:54,479
different

156
00:04:57,510 --> 00:04:56,320
and these differences so strong that

157
00:04:58,629 --> 00:04:57,520
they are in the order that we can

158
00:05:00,390 --> 00:04:58,639
potentially be

159
00:05:02,150 --> 00:05:00,400
potentially resolved with astronomical

160
00:05:04,150 --> 00:05:02,160
surveys

161
00:05:05,909 --> 00:05:04,160
um not only the size is so strongly

162
00:05:07,590 --> 00:05:05,919
different but also the plant looks

163
00:05:08,950 --> 00:05:07,600

very differently this is shown on the

164
00:05:11,990 --> 00:05:08,960
left hand side uh your

165
00:05:14,469 --> 00:05:12,000
contrasting h2o again with h2 this the

166
00:05:16,629 --> 00:05:14,479
y-axis here is the spectral flux density

167
00:05:18,390 --> 00:05:16,639
for a given wavelength this is basically

168
00:05:20,070 --> 00:05:18,400
how the planet looks like

169
00:05:22,550 --> 00:05:20,080
so astronomical surveys only progress

170
00:05:25,029 --> 00:05:22,560
specific length or a specific

171
00:05:26,070 --> 00:05:25,039
area of that wavelength range and this

172
00:05:29,110 --> 00:05:26,080
here for instance

173
00:05:32,150 --> 00:05:29,120
is the wavelength range of one

174
00:05:33,909 --> 00:05:32,160
of the future direct imaging survey

175
00:05:35,189 --> 00:05:33,919
that is currently in the concept phase

176
00:05:38,550 --> 00:05:35,199
um and

177
00:05:38,950 --> 00:05:38,560
these types of service will not only be

178
00:05:40,790 --> 00:05:38,960
able

179
00:05:41,990 --> 00:05:40,800
to actually see those types of planets

180
00:05:43,990 --> 00:05:42,000
but they will also be able to infer

181
00:05:45,350 --> 00:05:44,000
something about the interior state

182
00:05:47,189 --> 00:05:45,360
these are the different lines you see

183
00:05:48,870 --> 00:05:47,199
here so i don't have the time to really

184
00:05:50,390 --> 00:05:48,880
go into the details but

185
00:05:52,070 --> 00:05:50,400
these different lines show different

186
00:05:53,749 --> 00:05:52,080
interior properties for instance how the

187
00:05:55,670 --> 00:05:53,759
magma and the solid

188
00:05:57,270 --> 00:05:55,680

rocks behave when you see their order of

189
00:05:58,790 --> 00:05:57,280
magnitude differences for differing

190
00:06:00,469 --> 00:05:58,800
crystallization path

191
00:06:02,870 --> 00:06:00,479
and order of magnitude differences

192
00:06:05,110 --> 00:06:02,880
between compositions of the atmospheres

193
00:06:06,710 --> 00:06:05,120
and so when we will be able to see those

194
00:06:09,029 --> 00:06:06,720
planets we will be able to make out

195
00:06:11,590 --> 00:06:09,039
their differences and understand

196
00:06:12,629 --> 00:06:11,600
the diversity of these early portal and

197
00:06:15,749 --> 00:06:12,639
cooling

198
00:06:18,870 --> 00:06:15,759
magma ocean atmospheres now this is

199
00:06:21,670 --> 00:06:18,880
uh for the future but at the moment the

200
00:06:23,029 --> 00:06:21,680
um the question is really what how do

201
00:06:25,350 --> 00:06:23,039
larger planets behave

202
00:06:26,629 --> 00:06:25,360
this is potentially important because

203
00:06:28,230 --> 00:06:26,639
some of them specifically this

204
00:06:29,990 --> 00:06:28,240
class of so-called supers or

205
00:06:32,629 --> 00:06:30,000
sub-neptunes is

206
00:06:34,309 --> 00:06:32,639
dominated by rock stamas and so they are

207
00:06:35,909 --> 00:06:34,319
definitely related to the terrestrial

208
00:06:36,870 --> 00:06:35,919
planets at some to some it's to some

209
00:06:38,870 --> 00:06:36,880
extent

210
00:06:40,150 --> 00:06:38,880
and uh we can actually probe them today

211
00:06:41,510 --> 00:06:40,160
and specifically with the james webb

212
00:06:44,469 --> 00:06:41,520
space telescope

213
00:06:44,870 --> 00:06:44,479

um from next year on uh this here shows

214
00:06:46,950 --> 00:06:44,880
uh

215
00:06:49,350 --> 00:06:46,960
these are two famous members of this

216
00:06:50,950 --> 00:06:49,360
class this is gj1132b for which

217
00:06:53,830 --> 00:06:50,960
there has been a claimed detection of a

218
00:06:55,350 --> 00:06:53,840
reduced atmosphere this is k218b

219
00:06:58,390 --> 00:06:55,360
for which there's evidence for water in

220
00:07:01,990 --> 00:06:58,400
its atmosphere and

221
00:07:03,270 --> 00:07:02,000
the existence of these types of

222
00:07:04,710 --> 00:07:03,280
superheroes atmospheres is very

223
00:07:05,670 --> 00:07:04,720
important specifically the long-lived

224
00:07:07,670 --> 00:07:05,680
ones after

225
00:07:09,029 --> 00:07:07,680
the portal atmosphere has escaped

226
00:07:10,870 --> 00:07:09,039
because we can then

227
00:07:12,230 --> 00:07:10,880
if they if there are reduced super

228
00:07:15,350 --> 00:07:12,240
earths we would be able to

229
00:07:17,270 --> 00:07:15,360
probe prebiotic chemistry in action

230
00:07:20,469 --> 00:07:17,280
this here for instance this model

231
00:07:23,670 --> 00:07:20,479
spectrum of this planet gj1132b

232
00:07:26,629 --> 00:07:23,680
you see that for instance with with

233
00:07:28,830 --> 00:07:26,639
jbl wst neocam instrument we would be

234
00:07:31,749 --> 00:07:28,840
able to make out

235
00:07:33,430 --> 00:07:31,759
cyanoacetylene in the atmosphere

236
00:07:34,950 --> 00:07:33,440
using different markers so this is

237
00:07:35,350 --> 00:07:34,960
something very exciting to look forward

238
00:07:37,110 --> 00:07:35,360

to

239
00:07:38,550 --> 00:07:37,120
and potentially in the next few years we

240
00:07:40,469 --> 00:07:38,560
will actually get confirmation of these

241
00:07:44,070 --> 00:07:40,479
types of observations

242
00:07:46,309 --> 00:07:44,080
now this is exciting but it's

243
00:07:47,430 --> 00:07:46,319
debated in the community the reason one

244
00:07:49,510 --> 00:07:47,440
of the reasons is

245
00:07:51,189 --> 00:07:49,520
that we actually believe these secondary

246
00:07:53,189 --> 00:07:51,199
atmospheres and super earths should not

247
00:07:54,950 --> 00:07:53,199
be reduced they should be oxidized

248
00:07:56,390 --> 00:07:54,960
why is that the reason is that larger

249
00:07:58,390 --> 00:07:56,400
planets should in principle

250
00:07:59,430 --> 00:07:58,400
tend to be more oxidized because of

251
00:08:01,029 --> 00:07:59,440
geochemical

252
00:08:03,189 --> 00:08:01,039
reactions that operate in the interior

253
00:08:04,309 --> 00:08:03,199
of these planets so the principal idea

254
00:08:06,230 --> 00:08:04,319
is that if you have like something on

255
00:08:08,710 --> 00:08:06,240
the order of a moon or mass-sized planet

256
00:08:10,390 --> 00:08:08,720
you can host a reduced atmosphere but

257
00:08:11,430 --> 00:08:10,400
the larger you go the more oxidized you

258
00:08:14,150 --> 00:08:11,440
become

259
00:08:15,830 --> 00:08:14,160
and uh one of the main reasons for that

260
00:08:17,749 --> 00:08:15,840
specifically relevant for earth-sized

261
00:08:19,110 --> 00:08:17,759
planet is iron disproportionation

262
00:08:20,869 --> 00:08:19,120
the principle reaction here goes like

263
00:08:23,990 --> 00:08:20,879

this so we react

264
00:08:25,270 --> 00:08:24,000
fe2 plus an fe2 plus phase to fe3 plus

265
00:08:26,790 --> 00:08:25,280
plus a metallic iron

266
00:08:28,869 --> 00:08:26,800
for instance while the reaction silicate

267
00:08:29,510 --> 00:08:28,879
melt plus aluminum oxide makes periscope

268
00:08:31,830 --> 00:08:29,520
plus

269
00:08:32,949 --> 00:08:31,840
metal and this metal due to gravity then

270
00:08:34,949 --> 00:08:32,959
sinks to the core

271
00:08:36,630 --> 00:08:34,959
in this net oxidized instrumental and

272
00:08:38,870 --> 00:08:36,640
this means that the gases that come

273
00:08:40,149 --> 00:08:38,880
out of the mantle are rich in water and

274
00:08:44,630 --> 00:08:40,159
water and carbon dioxide

275
00:08:46,630 --> 00:08:44,640
for instance now that is not

276
00:08:47,990 --> 00:08:46,640
that is a standard picture but it may be

277
00:08:49,590 --> 00:08:48,000
fundamentally different

278
00:08:51,269 --> 00:08:49,600
in super earth actually this is what

279
00:08:54,550 --> 00:08:51,279
i've shown earlier this year

280
00:08:55,670 --> 00:08:54,560
because um the uh

281
00:08:57,750 --> 00:08:55,680
super hours are much larger and their

282
00:08:59,750 --> 00:08:57,760
gravity is much higher the convection

283
00:09:01,750 --> 00:08:59,760
interior is actually much more vigorous

284
00:09:03,590 --> 00:09:01,760
and people have not quantified this so

285
00:09:04,630 --> 00:09:03,600
far but it turns out using scaling

286
00:09:07,590 --> 00:09:04,640
analysis

287
00:09:08,310 --> 00:09:07,600
um that that the convection is so

288
00:09:09,829 --> 00:09:08,320

vigorous

289
00:09:11,509 --> 00:09:09,839
that these metal droplets don't have to

290
00:09:13,030 --> 00:09:11,519
sink actually in the to the mantle and

291
00:09:15,030 --> 00:09:13,040
they don't merge with the core

292
00:09:17,190 --> 00:09:15,040
that means that reducing power can be

293
00:09:17,910 --> 00:09:17,200
kept in stars is in the in the in the

294
00:09:20,470 --> 00:09:17,920
mantle

295
00:09:20,949 --> 00:09:20,480
and therefore uh redu super earth can

296
00:09:23,430 --> 00:09:20,959
still

297
00:09:25,670 --> 00:09:23,440
in principle host reduced atmospheres

298
00:09:27,750 --> 00:09:25,680
with h2 ch4 and nh3

299
00:09:29,829 --> 00:09:27,760
and their photochemical derivatives and

300
00:09:31,750 --> 00:09:29,839
this predicts that actually if

301
00:09:33,590 --> 00:09:31,760
magma oceans the magma dynamics and

302
00:09:35,430 --> 00:09:33,600
super earth should work like this

303
00:09:37,829 --> 00:09:35,440
then we would expect to see reduced

304
00:09:40,550 --> 00:09:37,839
surfaces versus in this case we would

305
00:09:42,470 --> 00:09:40,560
expect oxidized surfaces and because

306
00:09:44,070 --> 00:09:42,480
this this scenario enhances the chances

307
00:09:45,190 --> 00:09:44,080
for detection on long-lived reduced

308
00:09:46,710 --> 00:09:45,200
atmospheres

309
00:09:49,350 --> 00:09:46,720
we should in principle be able to probe

310
00:09:52,230 --> 00:09:49,360
this with near future observations

311
00:09:54,150 --> 00:09:52,240
now the uh prospect for observing

312
00:09:57,030 --> 00:09:54,160
surfaces actually very exciting

313
00:09:58,949 --> 00:09:57,040

and it probably has been done already uh

314
00:10:00,150 --> 00:09:58,959
for the specific famous case of lhs

315
00:10:01,430 --> 00:10:00,160
3844b

316
00:10:02,949 --> 00:10:01,440
he used the temperature map of the

317
00:10:03,990 --> 00:10:02,959
planetary surface from a very long

318
00:10:05,829 --> 00:10:04,000
spitzer space telescope

319
00:10:07,269 --> 00:10:05,839
campaign and this was the first planet

320
00:10:08,710 --> 00:10:07,279
for which we have actually temperature

321
00:10:09,990 --> 00:10:08,720
boundary conditions now from this

322
00:10:11,509 --> 00:10:10,000
temperature map here

323
00:10:13,670 --> 00:10:11,519
so here's the star this planet is

324
00:10:15,509 --> 00:10:13,680
tightly locked surface it's now facing

325
00:10:16,470 --> 00:10:15,519
site is in an eternal day it's hot but

326
00:10:18,790 --> 00:10:16,480
not molten

327
00:10:20,310 --> 00:10:18,800
and the night side is eternal night and

328
00:10:21,829 --> 00:10:20,320
it's freezing cold there's no atmosphere

329
00:10:23,350 --> 00:10:21,839
around so it's basically direct space

330
00:10:24,630 --> 00:10:23,360
boundary conditions

331
00:10:27,190 --> 00:10:24,640
because this was the first time we

332
00:10:29,670 --> 00:10:27,200
actually have a boundary condition for

333
00:10:31,110 --> 00:10:29,680
um for a super earth we use that and try

334
00:10:31,590 --> 00:10:31,120
to infer the geodynamic mode of that

335
00:10:32,949 --> 00:10:31,600
planet

336
00:10:34,150 --> 00:10:32,959
it turns out it's fundamentally

337
00:10:35,509 --> 00:10:34,160
different from anything that we see in

338
00:10:37,030 --> 00:10:35,519

the solar system

339
00:10:39,030 --> 00:10:37,040
this is what you see over here so here's

340
00:10:39,910 --> 00:10:39,040
the star this is a cut through the

341
00:10:41,990 --> 00:10:39,920
planet

342
00:10:43,829 --> 00:10:42,000
and this is a geodynamic model so what

343
00:10:44,230 --> 00:10:43,839
you see is basically the flow of the

344
00:10:46,630 --> 00:10:44,240
rock

345
00:10:47,670 --> 00:10:46,640
inside this is a solid state convection

346
00:10:49,190 --> 00:10:47,680
here's the metal core

347
00:10:51,030 --> 00:10:49,200
and here's the surface of the planet you

348
00:10:53,430 --> 00:10:51,040
see upwellings in the dayside

349
00:10:55,030 --> 00:10:53,440
and cold down wellings on the night side

350
00:10:56,310 --> 00:10:55,040
this is actually not a preferred model

351
00:10:57,590 --> 00:10:56,320
because we think that the

352
00:10:59,590 --> 00:10:57,600
lithosphere on these types of plants

353
00:10:59,990 --> 00:10:59,600
should be very strong in that case

354
00:11:02,790 --> 00:11:00,000
something

355
00:11:04,310 --> 00:11:02,800
very unintuitive happens namely that

356
00:11:05,990 --> 00:11:04,320
actually the day side is the prominent

357
00:11:08,470 --> 00:11:06,000
location for downwellings

358
00:11:09,190 --> 00:11:08,480
and the the night side actually should

359
00:11:10,630 --> 00:11:09,200
feature

360
00:11:12,470 --> 00:11:10,640
more upwellings and therefore also

361
00:11:14,389 --> 00:11:12,480
volcanic outpourings

362
00:11:15,990 --> 00:11:14,399
and this actually predicts that the

363
00:11:18,389 --> 00:11:16,000

volatile recycling pattern

364
00:11:20,310 --> 00:11:18,399
on these types of planets should go like

365
00:11:23,590 --> 00:11:20,320
depicted here so from the day side

366
00:11:25,269 --> 00:11:23,600
down to the mantle and through volcanic

367
00:11:26,389 --> 00:11:25,279
outgassing be released again on the

368
00:11:28,069 --> 00:11:26,399
night side

369
00:11:30,230 --> 00:11:28,079
and this is again something that we will

370
00:11:32,550 --> 00:11:30,240
be able to observe with jwst

371
00:11:35,350 --> 00:11:32,560
specifically this planet is targeted for

372
00:11:38,550 --> 00:11:35,360
a observation campaign next year

373
00:11:41,269 --> 00:11:38,560
and with that um i want to finish um

374
00:11:42,150 --> 00:11:41,279
and just to summarize so hopefully we

375
00:11:43,829 --> 00:11:42,160
will be able

376
00:11:45,190 --> 00:11:43,839
uh using astronomical observations to

377
00:11:46,389 --> 00:11:45,200
infer the composition of secondary

378
00:11:48,310 --> 00:11:46,399
atmosphere

379
00:11:49,590 --> 00:11:48,320
which constrains the mental redox state

380
00:11:50,629 --> 00:11:49,600
and volatile budget

381
00:11:52,150 --> 00:11:50,639
and tells us something about the

382
00:11:53,269 --> 00:11:52,160
interaction with hot molten mantles and

383
00:11:54,629 --> 00:11:53,279
the atmospheres

384
00:11:56,389 --> 00:11:54,639
and therefore informs the planetary

385
00:11:57,829 --> 00:11:56,399
environment of the aden earth