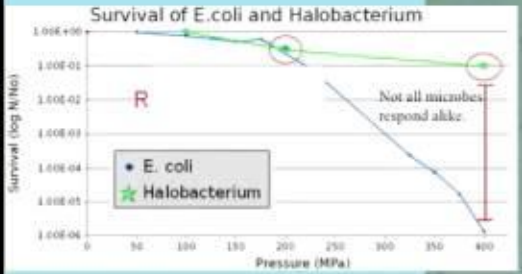
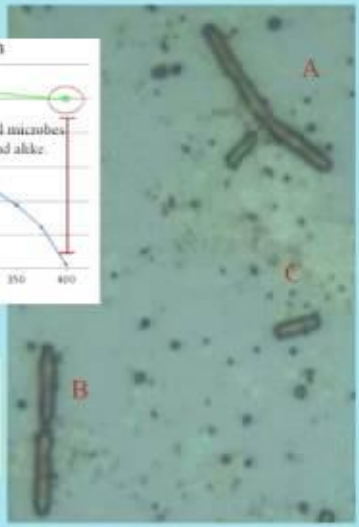
NASA Astrobiology Institute

Team Overview Seminars
Carnegie Institution of Washington

Adaption of Halophiles to High Pressure: Griffin, Kish, & Steele





Pressurized *E.coli* elongate (A), divide upon depressurization (B) and finally return to normal size (C).

[Griffin *et al., to be published*]

1
00:00:07,400 --> 00:00:03,290
okay hello everyone and welcome to the

2
00:00:11,270 --> 00:00:07,410
first of the 14 virtual seminars by all

3
00:00:14,330 --> 00:00:11,280
of the nai teams George we're really

4
00:00:18,950 --> 00:00:14,340
happy to have you lead this off I tried

5
00:00:20,599 --> 00:00:18,960
to look up George's CV before this but

6
00:00:22,880 --> 00:00:20,609
actually couldn't find it on the web to

7
00:00:26,120 --> 00:00:22,890
give you the usual kind of rundown on

8
00:00:28,189 --> 00:00:26,130
where we got his PhD etc I suspect

9
00:00:29,779 --> 00:00:28,199
that's not entirely necessary since

10
00:00:32,420 --> 00:00:29,789
George is pretty well known to everybody

11
00:00:37,310 --> 00:00:32,430
in this community is an organic

12
00:00:39,799 --> 00:00:37,320
geochemistry anelia rights and organic

13
00:00:41,840 --> 00:00:39,809

chemistry on the earth and he's going to

14
00:00:44,750 --> 00:00:41,850
tell us of course about what the

15
00:00:47,569 --> 00:00:44,760
Carnegie team is doing and without any

16
00:00:49,639 --> 00:00:47,579
further ado I'm going to turn it over to

17
00:00:51,650 --> 00:00:49,649
George actually one slight piece of

18
00:00:54,350 --> 00:00:51,660
further ado just to remind you all that

19
00:00:56,450 --> 00:00:54,360
George's seminar along with all the

20
00:00:58,849 --> 00:00:56,460
others will be archived on the NAI

21
00:01:00,889 --> 00:00:58,859
website so anybody who couldn't

22
00:01:03,709 --> 00:01:00,899
participate in the seminar right now

23
00:01:06,190 --> 00:01:03,719
we'll have the opportunity to see the

24
00:01:09,050 --> 00:01:06,200
whole thing in almost its full glory

25
00:01:11,410 --> 00:01:09,060
within a few days and you'll just go to

26
00:01:14,210 --> 00:01:11,420
the seminar page on the NAI website and

27
00:01:17,060 --> 00:01:14,220
now without further ado George take it

28
00:01:19,340 --> 00:01:17,070
away please well thanks Carl so yeah

29
00:01:21,649 --> 00:01:19,350
we're leading this off we were we were

30
00:01:25,039 --> 00:01:21,659
called to to rise to the challenge of

31
00:01:28,460 --> 00:01:25,049
being the first to do so I'll tell you a

32
00:01:30,499 --> 00:01:28,470
little bit the title of our Institute is

33
00:01:32,030 --> 00:01:30,509
that's a biological pathways from the

34
00:01:33,469 --> 00:01:32,040
tell interstellar medium through the

35
00:01:36,140 --> 00:01:33,479
planetary systems the emergence and

36
00:01:37,460 --> 00:01:36,150
detection of light we've been involved

37
00:01:39,289 --> 00:01:37,470
the carnegie institution has been

38
00:01:42,590 --> 00:01:39,299

involved with with nai for quite some

39
00:01:47,960 --> 00:01:42,600
time we were selected in the first can

40
00:01:51,230 --> 00:01:47,970
we were resected in cam 3 at that time

41
00:01:54,039 --> 00:01:51,240
our institute was led by Sean Solomon he

42
00:01:57,620 --> 00:01:54,049
is the pi/4 the messenger missing and

43
00:01:59,480 --> 00:01:57,630
realized that a cam 5 he was it's not

44
00:02:01,490 --> 00:01:59,490
possible for him to leave this and also

45
00:02:04,609 --> 00:02:01,500
be a full p I participant in the

46
00:02:06,530 --> 00:02:04,619
messenger business historical so I took

47
00:02:11,270 --> 00:02:06,540
over the role as P I week in each

48
00:02:12,949 --> 00:02:11,280
iteration we've changed a lot so each

49
00:02:14,180 --> 00:02:12,959
can is this very very different than the

50
00:02:16,090 --> 00:02:14,190
one preceded it

51
00:02:19,280 --> 00:02:16,100
partly because our own scientific

52
00:02:20,480 --> 00:02:19,290
evolution and and also we found things

53
00:02:22,570 --> 00:02:20,490
that worked and things that we thought

54
00:02:25,550 --> 00:02:22,580
could work better if we change things

55
00:02:27,650 --> 00:02:25,560
currently we have 24 investigators six

56
00:02:35,360 --> 00:02:27,660
institutions Carnegie Institution

57
00:02:36,770 --> 00:02:35,370
watney's is the lead institution johns

58
00:02:39,320 --> 00:02:36,780
hopkins university is a new

59
00:02:42,260 --> 00:02:39,330
participating institution university of

60
00:02:44,000 --> 00:02:42,270
washington has been involved with us in

61
00:02:45,950 --> 00:02:44,010
the very beginning with John barrows and

62
00:02:49,130 --> 00:02:45,960
his students and postdocs University of

63
00:02:51,500 --> 00:02:49,140

Maryland James Farquhar continues from

64
00:02:53,600 --> 00:02:51,510
cam 3 & 2 km five of the naval research

65
00:02:56,570 --> 00:02:53,610
laboratory with kawaii Rhonda Stroud

66
00:02:58,330 --> 00:02:56,580
continues from camp 3 and a new

67
00:03:02,090 --> 00:02:58,340
participant is East Carolina University

68
00:03:03,950 --> 00:03:02,100
where the kauai is matt shrank there'll

69
00:03:05,750 --> 00:03:03,960
be a little bit of delay i apologize

70
00:03:08,000 --> 00:03:05,760
we'll have to get used to this as we

71
00:03:09,260 --> 00:03:08,010
switch slides around what i'm going to

72
00:03:12,530 --> 00:03:09,270
do today which may be a little different

73
00:03:14,420 --> 00:03:12,540
is i'm going to ask the co eyes who

74
00:03:17,900 --> 00:03:14,430
represent different areas to describe

75
00:03:20,180 --> 00:03:17,910
some of the areas that that constitute

76
00:03:23,180 --> 00:03:20,190
our institution we basically have six

77
00:03:24,710 --> 00:03:23,190
primary themes line is the studies

78
00:03:27,350 --> 00:03:24,720
physical chemical evolution of planetary

79
00:03:29,990 --> 00:03:27,360
systems to the origin evolution of

80
00:03:31,820 --> 00:03:30,000
organic matter in the solar system three

81
00:03:34,040 --> 00:03:31,830
is more of a terrestrial of planetary

82
00:03:35,570 --> 00:03:34,050
vol tools a component the origin

83
00:03:37,760 --> 00:03:35,580
evolution inventory of volatiles and

84
00:03:39,740 --> 00:03:37,770
terrestrial planets and link to that is

85
00:03:43,729 --> 00:03:39,750
the geochemical steps leading to the

86
00:03:47,150 --> 00:03:43,739
origins of life and five is geological

87
00:03:49,250 --> 00:03:47,160
and biological interactions so there's a

88
00:03:51,470 --> 00:03:49,260

real sense of flow from from the

89
00:03:53,840 --> 00:03:51,480
formation section formation of planets

90
00:03:57,170 --> 00:03:53,850
to ultimately biological systems and

91
00:03:59,660 --> 00:03:57,180
finally task six is linked in

92
00:04:01,940 --> 00:03:59,670
astrobiology link if you will to to our

93
00:04:04,330 --> 00:04:01,950
field studies and integrating that with

94
00:04:06,380 --> 00:04:04,340
laboratory flight experiment

95
00:04:09,410 --> 00:04:06,390
experimentation of flight instrument

96
00:04:11,990 --> 00:04:09,420
testing so task 2 and 1 are essentially

97
00:04:13,490 --> 00:04:12,000
astro chemical Astrophysical in nature

98
00:04:15,620 --> 00:04:13,500
and Alicia Weinberger who's sitting on

99
00:04:18,789 --> 00:04:15,630
my left will discuss the subtasks their

100
00:04:20,449 --> 00:04:18,799
task three and four link to two

101
00:04:22,820 --> 00:04:20,459
fundamental issues related to

102
00:04:25,159 --> 00:04:22,830
terrestrial planet formation and early

103
00:04:26,630 --> 00:04:25,169
evolution and Steve shayari sits on my

104
00:04:27,520 --> 00:04:26,640
right we'll we'll lead through those

105
00:04:29,379 --> 00:04:27,530
sections

106
00:04:31,420 --> 00:04:29,389
and the task five and six the gia

107
00:04:33,610 --> 00:04:31,430
biological geological biological

108
00:04:36,730 --> 00:04:33,620
interactions and the field work

109
00:04:38,560 --> 00:04:36,740
associated this would be held discussed

110
00:04:40,540 --> 00:04:38,570
by Marilyn Fogle who's sitting on my far

111
00:04:44,379 --> 00:04:40,550
left so I'm going to turn this over to

112
00:04:46,150 --> 00:04:44,389
Alicia and when this next slide comes up

113
00:04:50,200 --> 00:04:46,160

she will take you through task one and

114
00:04:51,970 --> 00:04:50,210
two thanks George so we're going to

115
00:04:53,890 --> 00:04:51,980
start with studies of the physical and

116
00:04:56,170 --> 00:04:53,900
chemical evolution of planetary systems

117
00:04:57,940 --> 00:04:56,180
and it starts with astronomical

118
00:04:59,890 --> 00:04:57,950
observations that inform our

119
00:05:02,110 --> 00:04:59,900
understanding of the diversity of

120
00:05:05,950 --> 00:05:02,120
planetary systems and the history of our

121
00:05:08,110 --> 00:05:05,960
own solar system you can see they're all

122
00:05:09,820 --> 00:05:08,120
of the co eyes who participate in these

123
00:05:13,090 --> 00:05:09,830
but you don't have to read them all talk

124
00:05:16,090 --> 00:05:13,100
about the h and turn so first we'll

125
00:05:19,210 --> 00:05:16,100
start with searches for planets and that

126
00:05:20,920 --> 00:05:19,220
begins with my co investigator Paul

127
00:05:23,320 --> 00:05:20,930
Butler who is one of the preeminent

128
00:05:25,450 --> 00:05:23,330
planted planet hunters using the radial

129
00:05:28,900 --> 00:05:25,460
velocity method for finding planets and

130
00:05:30,730 --> 00:05:28,910
on this slide you can see a plot from

131
00:05:32,350 --> 00:05:30,740
his work showing the number of planets

132
00:05:35,560 --> 00:05:32,360
that have been discovered as a function

133
00:05:37,420 --> 00:05:35,570
of mass and are now about 340 planets

134
00:05:39,010 --> 00:05:37,430
known they're mostly known from this

135
00:05:41,740 --> 00:05:39,020
radial velocity method so that is

136
00:05:44,409 --> 00:05:41,750
looking at the motion of a star toward

137
00:05:46,840 --> 00:05:44,419
and away from you as it's tugged by a

138
00:05:49,150 --> 00:05:46,850

planet that is going around it the

139
00:05:51,400 --> 00:05:49,160
lowest mass planet that's been found is

140
00:05:52,750 --> 00:05:51,410
about 5 Earth masses and maybe one has

141
00:05:55,719 --> 00:05:52,760
been discovered and what we will call a

142
00:05:58,480 --> 00:05:55,729
habitable zone so the challenge for the

143
00:06:02,440 --> 00:05:58,490
future is to find planets of lower mass

144
00:06:05,800 --> 00:06:02,450
and to find them in the habitable zones

145
00:06:07,450 --> 00:06:05,810
of sun-like stars so the challenge there

146
00:06:10,120 --> 00:06:07,460
is to get better radial velocity

147
00:06:13,860 --> 00:06:10,130
precision and what you can see here are

148
00:06:16,120 --> 00:06:13,870
these blue lines like this one that show

149
00:06:18,400 --> 00:06:16,130
what the precision that can be achieved

150
00:06:20,560 --> 00:06:18,410
in the next couple now and in the next

151
00:06:22,840 --> 00:06:20,570
couple of years is and that's a three

152
00:06:24,640 --> 00:06:22,850
sigma of about three meters per second

153
00:06:26,290 --> 00:06:24,650
you have to stop and think about that

154
00:06:29,920 --> 00:06:26,300
number if you haven't before because

155
00:06:31,240 --> 00:06:29,930
that's like a fast sprint right so kind

156
00:06:34,300 --> 00:06:31,250
of amazing that you can measure that

157
00:06:37,120 --> 00:06:34,310
around a star that is at you know 15

158
00:06:39,610 --> 00:06:37,130
parsecs or some distance away so this

159
00:06:40,959 --> 00:06:39,620
plot shows stars that have already been

160
00:06:42,879 --> 00:06:40,969
discovered to have planets

161
00:06:44,589 --> 00:06:42,889
in the orange dots kind of what the

162
00:06:46,600 --> 00:06:44,599
state of the art has been for the last

163
00:06:48,819 --> 00:06:46,610

few years that's about 10 meters per

164
00:06:50,949 --> 00:06:48,829
second three sigma and where Paul is

165
00:06:52,839 --> 00:06:50,959
attempting to push the technique over

166
00:06:55,509 --> 00:06:52,849
the last couple of years next couple of

167
00:06:58,689 --> 00:06:55,519
years which is a very consistent 3 Sigma

168
00:07:00,399 --> 00:06:58,699
of 3 meters per second and also shown on

169
00:07:04,809 --> 00:07:00,409
here in the green and in the purple

170
00:07:06,609 --> 00:07:04,819
lines are the limits that one could get

171
00:07:07,989 --> 00:07:06,619
from astrometric measurements and i'll

172
00:07:10,059 --> 00:07:07,999
come back to those in a couple of

173
00:07:12,039 --> 00:07:10,069
minutes but I think what you can tell

174
00:07:14,499 --> 00:07:12,049
from this is that around sun-like stars

175
00:07:16,899 --> 00:07:14,509
the technique that's really going to

176
00:07:18,759 --> 00:07:16,909
probe to the lowest mass planets and at

177
00:07:20,709 --> 00:07:18,769
interesting separations from the star

178
00:07:24,129 --> 00:07:20,719
and the next few years is going to be

179
00:07:27,009 --> 00:07:24,139
the radial velocity technique and this

180
00:07:29,979 --> 00:07:27,019
next slide when it comes up is going to

181
00:07:32,049 --> 00:07:29,989
show a simulation of what radial

182
00:07:35,679 --> 00:07:32,059
velocity could do with a precision of

183
00:07:38,439 --> 00:07:35,689
one meter per second and long telescope

184
00:07:40,569 --> 00:07:38,449
runs so that you can really get a

185
00:07:42,819 --> 00:07:40,579
cadence necessary to observe something

186
00:07:44,739 --> 00:07:42,829
that orbits its star frequently and this

187
00:07:46,659 --> 00:07:44,749
particular simulation was done for a

188
00:07:48,579 --> 00:07:46,669

half a solar mass star and that places

189
00:07:51,399 --> 00:07:48,589
the habitable zone at about a period of

190
00:07:54,939 --> 00:07:51,409
50 days so this is for a 5 earth-mass

191
00:07:56,409 --> 00:07:54,949
planet and on the top plot you see what

192
00:07:58,540 --> 00:07:56,419
it would look like if you actually took

193
00:08:01,540 --> 00:07:58,550
data with a precision of about a meter

194
00:08:04,389 --> 00:08:01,550
per second every day for a year and then

195
00:08:06,429 --> 00:08:04,399
if you did an analysis of those data you

196
00:08:08,350 --> 00:08:06,439
would find that in a power spectrum the

197
00:08:09,969 --> 00:08:08,360
period of 50 days does indeed come up

198
00:08:12,819 --> 00:08:09,979
very strongly and so you could detect

199
00:08:15,039 --> 00:08:12,829
that five earth-mass planet although you

200
00:08:17,139 --> 00:08:15,049
can see that that planet produces a

201
00:08:18,939 --> 00:08:17,149
signal of about a meter per second and

202
00:08:20,379 --> 00:08:18,949
so it's very difficult this is the

203
00:08:24,789 --> 00:08:20,389
cutting edge of what they'll be able to

204
00:08:27,039 --> 00:08:24,799
do in the next few years and Paul okay

205
00:08:29,859 --> 00:08:27,049
Paul will be commissioning a new

206
00:08:31,779 --> 00:08:29,869
spectrograph on the Magellan telescope

207
00:08:34,209 --> 00:08:31,789
at last components Observatory this year

208
00:08:36,939 --> 00:08:34,219
that will hopefully do better on and do

209
00:08:38,980 --> 00:08:36,949
meter per second precision and another

210
00:08:40,449 --> 00:08:38,990
of our co-investigators John Chambers is

211
00:08:44,049 --> 00:08:40,459
working on advanced computational

212
00:08:46,240 --> 00:08:44,059
techniques in order to tease out planets

213
00:08:49,710 --> 00:08:46,250

especially multiple planet systems from

214
00:08:51,639 --> 00:08:49,720
radial velocity data so i mentioned

215
00:08:55,629 --> 00:08:51,649
astrometry as another

216
00:08:57,549 --> 00:08:55,639
technique for finding planets and the we

217
00:08:59,499 --> 00:08:57,559
also have an astromech planet search

218
00:09:00,999 --> 00:08:59,509
going on at last campanas observatory on

219
00:09:02,859 --> 00:09:01,009
the dupont telescope with a brand-new

220
00:09:05,410 --> 00:09:02,869
camera that just flashed up there called

221
00:09:07,780 --> 00:09:05,420
caps cam this is a project led by alan

222
00:09:09,369 --> 00:09:07,790
boss although i'm a co-investigator so

223
00:09:11,139 --> 00:09:09,379
if we now start thinking about estranha

224
00:09:12,999 --> 00:09:11,149
tree instead of radial velocity that's

225
00:09:14,919 --> 00:09:13,009
watching the motion of a star on the

226
00:09:17,169 --> 00:09:14,929
plane of the sky as its tugged on by a

227
00:09:20,259 --> 00:09:17,179
planet going around it instead of toward

228
00:09:22,269 --> 00:09:20,269
and away from you and as you the

229
00:09:24,400 --> 00:09:22,279
astrometric signal is increased by

230
00:09:26,530 --> 00:09:24,410
having a lower mass star so that a

231
00:09:29,499 --> 00:09:26,540
planet of a given mass makes it move

232
00:09:31,720 --> 00:09:29,509
more and also by looking at stars that

233
00:09:33,549 --> 00:09:31,730
are very nearby because that way they

234
00:09:37,960 --> 00:09:33,559
their apparent motion on the sky is

235
00:09:40,030 --> 00:09:37,970
larger and in this case then you're

236
00:09:42,819 --> 00:09:40,040
driven to look at lower mass stars and

237
00:09:44,350 --> 00:09:42,829
stars that are very nearby so for solar

238
00:09:46,090 --> 00:09:44,360

type stars like the ones that Paul

239
00:09:48,069 --> 00:09:46,100
Butler is interested in in order to get

240
00:09:50,379 --> 00:09:48,079
a reasonable sample like a hundred stars

241
00:09:54,280 --> 00:09:50,389
you'd have to go out to a distance of

242
00:09:56,079 --> 00:09:54,290
about 30 parsecs from the Sun whereas to

243
00:09:58,150 --> 00:09:56,089
get a sample of very low mass stars

244
00:10:00,639 --> 00:09:58,160
those are the m-type stars or even brown

245
00:10:05,139 --> 00:10:00,649
dwarfs you only have to go out to 5 to

246
00:10:08,350 --> 00:10:05,149
10 parsecs to get 100 stars and so now a

247
00:10:11,949 --> 00:10:08,360
precision of 250 micro arc seconds which

248
00:10:15,150 --> 00:10:11,959
is the yellow line and this plot enables

249
00:10:17,889 --> 00:10:15,160
you to detect Jovian mass planet at

250
00:10:21,069 --> 00:10:17,899
interesting distances astronomical units

251
00:10:22,780 --> 00:10:21,079
or scales from nearby low mass stars and

252
00:10:24,939 --> 00:10:22,790
that's the principle of the astrometric

253
00:10:26,949 --> 00:10:24,949
planet search and it should be going on

254
00:10:31,660 --> 00:10:26,959
at last Campanas Observatory for the

255
00:10:33,549 --> 00:10:31,670
next decade so studies of extrasolar

256
00:10:36,129 --> 00:10:33,559
planetary systems have already shown

257
00:10:38,230 --> 00:10:36,139
that most planetary systems are not like

258
00:10:40,749 --> 00:10:38,240
our own right they contain planets at a

259
00:10:42,789 --> 00:10:40,759
wide range of eccentricities at a wide

260
00:10:45,460 --> 00:10:42,799
range of separations from their central

261
00:10:47,590 --> 00:10:45,470
stars you have low-mass planets that can

262
00:10:49,629 --> 00:10:47,600
be further out or closer in so a

263
00:10:51,519 --> 00:10:49,639

fundamental question that we want to ask

264
00:10:53,889 --> 00:10:51,529
for biological question we want to ask

265
00:10:55,780 --> 00:10:53,899
is how did our system come to be

266
00:10:57,999 --> 00:10:55,790
habitable how did we wind up with a

267
00:11:00,190 --> 00:10:58,009
planetary architecture that allowed us

268
00:11:02,140 --> 00:11:00,200
to have a habitable earth

269
00:11:03,940 --> 00:11:02,150
and that is the question that's asked by

270
00:11:06,130 --> 00:11:03,950
a Scott Shepherd the next of our

271
00:11:08,770 --> 00:11:06,140
co-investigators by studying the small

272
00:11:10,930 --> 00:11:08,780
bodies in our solar system so this slide

273
00:11:14,440 --> 00:11:10,940
shows a cartoon of the solar system

274
00:11:16,450 --> 00:11:14,450
where we have currently today reservoirs

275
00:11:19,270 --> 00:11:16,460
of small bodies that is asteroids and

276
00:11:22,030 --> 00:11:19,280
comets primarily in the Kuiper belt out

277
00:11:24,730 --> 00:11:22,040
at 50 or so astronomical units from the

278
00:11:26,860 --> 00:11:24,740
Sun and the Oort cloud much further away

279
00:11:29,350 --> 00:11:26,870
but the important thing is that those

280
00:11:31,300 --> 00:11:29,360
bodies came to be where they are and

281
00:11:33,910 --> 00:11:31,310
then the dynamical distributions in

282
00:11:35,740 --> 00:11:33,920
which they are because of the

283
00:11:37,300 --> 00:11:35,750
interaction with the giant planets and

284
00:11:40,990 --> 00:11:37,310
so it's the architecture of our

285
00:11:43,180 --> 00:11:41,000
planetary system that resulted in the

286
00:11:45,730 --> 00:11:43,190
locations of the small bodies as we see

287
00:11:47,380 --> 00:11:45,740
them today and in particular there are

288
00:11:49,570 --> 00:11:47,390

some bodies that are very hard to

289
00:11:51,850 --> 00:11:49,580
understand given what we know about the

290
00:11:54,730 --> 00:11:51,860
architecture of our system and so for

291
00:11:56,830 --> 00:11:54,740
example said no which is one object that

292
00:11:59,200 --> 00:11:56,840
people may call the first detected in ER

293
00:12:02,590 --> 00:11:59,210
Oort cloud object or it's the furthest

294
00:12:04,450 --> 00:12:02,600
detected Kuiper belt object it's very

295
00:12:06,160 --> 00:12:04,460
difficult to understand how it got in

296
00:12:08,350 --> 00:12:06,170
its present orbit it's in a highly

297
00:12:10,750 --> 00:12:08,360
eccentric orbit that takes it only about

298
00:12:13,060 --> 00:12:10,760
seven da you from the star from our Sun

299
00:12:15,790 --> 00:12:13,070
at closest approach so there are a

300
00:12:18,490 --> 00:12:15,800
couple of possibilities either we had an

301
00:12:21,010 --> 00:12:18,500
encounter with a nearby star or perhaps

302
00:12:23,680 --> 00:12:21,020
there's an unseen planet out in the

303
00:12:27,280 --> 00:12:23,690
Kuiper belt that modified Sedna's orbit

304
00:12:29,500 --> 00:12:27,290
and so Scott Shepherds project in the

305
00:12:31,540 --> 00:12:29,510
next couple of years is to search for

306
00:12:33,850 --> 00:12:31,550
more of these objects with strange

307
00:12:36,340 --> 00:12:33,860
dynamical and formation histories such

308
00:12:39,460 --> 00:12:36,350
as Sedna so he's going to do a very deep

309
00:12:41,440 --> 00:12:39,470
very wide field survey looking for

310
00:12:43,330 --> 00:12:41,450
objects in the outer Kuiper belt and on

311
00:12:45,580 --> 00:12:43,340
this slide you can see kind of the state

312
00:12:48,190 --> 00:12:45,590
of what's known today for small bodies

313
00:12:50,440 --> 00:12:48,200

in the outer solar system most of these

314
00:12:52,750 --> 00:12:50,450
bodies can be explained by having had

315
00:12:55,600 --> 00:12:52,760
interaction interactions with the giant

316
00:12:57,820 --> 00:12:55,610
planets and Sedna in a class of only a

317
00:12:59,860 --> 00:12:57,830
couple of objects at this point that

318
00:13:01,540 --> 00:12:59,870
really seemed to have had dynamical

319
00:13:03,460 --> 00:13:01,550
interactions that we can't understand

320
00:13:05,080 --> 00:13:03,470
just by the giant planets and so Scott

321
00:13:07,330 --> 00:13:05,090
will be looking for more of those and

322
00:13:09,250 --> 00:13:07,340
trying to understand based on the

323
00:13:11,490 --> 00:13:09,260
distribution of those small bodies what

324
00:13:17,400 --> 00:13:11,500
had to have happened in our early

325
00:13:19,350 --> 00:13:17,410
solar system so we can do analogous work

326
00:13:21,540 --> 00:13:19,360
to looking at the small bodies in our

327
00:13:23,280 --> 00:13:21,550
solar system by looking at the disks

328
00:13:25,770 --> 00:13:23,290
around other stars and that's my

329
00:13:29,430 --> 00:13:25,780
interest but I won't spend the next 15

330
00:13:31,470 --> 00:13:29,440
slides on it I promise so here is an

331
00:13:33,300 --> 00:13:31,480
image that we took with the Hubble Space

332
00:13:37,710 --> 00:13:33,310
Telescope of the disk around another

333
00:13:39,680 --> 00:13:37,720
star HR 47 96a and the dust that's in

334
00:13:42,030 --> 00:13:39,690
this system is created by the

335
00:13:44,160 --> 00:13:42,040
evaporation or the collisions of

336
00:13:46,260 --> 00:13:44,170
planetesimals the equivalent to the

337
00:13:48,600 --> 00:13:46,270
asteroids and comets in our own system

338
00:13:51,480 --> 00:13:48,610

and so when we look at these systems

339
00:13:53,460 --> 00:13:51,490
it's that kind of population of small

340
00:13:55,590 --> 00:13:53,470
bodies that we're looking at and we try

341
00:13:57,660 --> 00:13:55,600
to relate that back to what we see in

342
00:13:59,820 --> 00:13:57,670
the small bodies in our own system and

343
00:14:01,740 --> 00:13:59,830
in this particular image one of the

344
00:14:03,570 --> 00:14:01,750
interesting things that that you can

345
00:14:06,210 --> 00:14:03,580
measure although it's very hard to see

346
00:14:08,190 --> 00:14:06,220
visually is that one side of the disc

347
00:14:10,710 --> 00:14:08,200
thus brighter side on the left is

348
00:14:13,620 --> 00:14:10,720
actually slightly closer to the central

349
00:14:16,290 --> 00:14:13,630
star then the opposite side of the disc

350
00:14:19,560 --> 00:14:16,300
is so the disc probably has some small

351
00:14:22,290 --> 00:14:19,570
intrinsic eccentricity and one way to

352
00:14:24,720 --> 00:14:22,300
get intrinsic eccentricities in the

353
00:14:27,180 --> 00:14:24,730
population of small bodies is to

354
00:14:29,520 --> 00:14:27,190
generate them with an eccentricity of a

355
00:14:32,880 --> 00:14:29,530
planet in the system and we do know that

356
00:14:34,740 --> 00:14:32,890
in most other planetary systems the

357
00:14:37,560 --> 00:14:34,750
planets are in eccentric orbits and not

358
00:14:40,829 --> 00:14:37,570
in circular orbits so furthermore we

359
00:14:43,860 --> 00:14:40,839
know that this system went at least as

360
00:14:46,500 --> 00:14:43,870
far as making planetesimals in terms of

361
00:14:48,420 --> 00:14:46,510
growing things into planets and it might

362
00:14:50,070 --> 00:14:48,430
be analogous to what the early solar

363
00:14:52,110 --> 00:14:50,080

system look like at a time when there

364
00:14:54,030 --> 00:14:52,120
was a much denser population of small

365
00:14:56,910 --> 00:14:54,040
bodies than there is in the solar system

366
00:14:58,740 --> 00:14:56,920
today now on the right you see the color

367
00:15:00,780 --> 00:14:58,750
of this disk which is very red and I'll

368
00:15:03,240 --> 00:15:00,790
come back to that color in a couple of

369
00:15:08,550 --> 00:15:03,250
minutes when I talk about the study of

370
00:15:10,260 --> 00:15:08,560
organics in our system so now you've

371
00:15:11,850 --> 00:15:10,270
seen a little bit of the flavor of what

372
00:15:14,010 --> 00:15:11,860
we're doing on the diversity of

373
00:15:15,960 --> 00:15:14,020
planetary systems and trying to

374
00:15:18,240 --> 00:15:15,970
understand the architecture of other

375
00:15:20,550 --> 00:15:18,250
planetary systems and of the origin of

376
00:15:24,000 --> 00:15:20,560
the architecture of our habitable system

377
00:15:24,960 --> 00:15:24,010
but even if we understood all of that we

378
00:15:28,019 --> 00:15:24,970
would still have

379
00:15:31,350 --> 00:15:28,029
a question or try to understand how we

380
00:15:33,780 --> 00:15:31,360
managed to get a habitable planet in our

381
00:15:36,720 --> 00:15:33,790
particular architecture and that is tied

382
00:15:38,429 --> 00:15:36,730
up with how you deliver the materials to

383
00:15:41,069 --> 00:15:38,439
the early Earth that you need in order

384
00:15:43,319 --> 00:15:41,079
to form interesting biochemistry in

385
00:15:45,600 --> 00:15:43,329
order to have habitability and so the

386
00:15:47,519 --> 00:15:45,610
second major thrust of research in our

387
00:15:49,619 --> 00:15:47,529
astrobiology group is the origin and

388
00:15:51,199 --> 00:15:49,629

evolution of organic matter in the solar

389
00:15:53,249 --> 00:15:51,209
system and you can see the

390
00:15:56,220 --> 00:15:53,259
co-investigators on this slide who are

391
00:16:00,269 --> 00:15:56,230
involved in that project and this again

392
00:16:02,100 --> 00:16:00,279
this spans now astronomers to laboratory

393
00:16:04,350 --> 00:16:02,110
astrophysicists as I like to call my

394
00:16:08,699 --> 00:16:04,360
colleagues of meteor it assists and

395
00:16:10,879 --> 00:16:08,709
organic chemists so the first thing we

396
00:16:13,769 --> 00:16:10,889
can do is ask in our own solar system

397
00:16:16,590 --> 00:16:13,779
where we can really measure the current

398
00:16:17,879 --> 00:16:16,600
day population of small bodies what are

399
00:16:20,819 --> 00:16:17,889
they made out of and do they have

400
00:16:22,740 --> 00:16:20,829
interesting organic contents and so this

401
00:16:25,199 --> 00:16:22,750
again is a project that Scott Shepherd

402
00:16:26,850 --> 00:16:25,209
is interested in where he looks at the

403
00:16:29,429 --> 00:16:26,860
colors of bodies in the outer solar

404
00:16:31,230 --> 00:16:29,439
system in the Kuiper belt and this shows

405
00:16:32,999 --> 00:16:31,240
and if you're not an astronomer are not

406
00:16:35,369 --> 00:16:33,009
used to looking at color color diagrams

407
00:16:36,869 --> 00:16:35,379
basically it shows how red objects are

408
00:16:38,790 --> 00:16:36,879
as you move to the upper right of the

409
00:16:41,340 --> 00:16:38,800
diagram you get objects that are redder

410
00:16:43,530 --> 00:16:41,350
and redder and there's a class of

411
00:16:47,100 --> 00:16:43,540
objects that Scott calls ultra red and

412
00:16:49,259 --> 00:16:47,110
our best idea for how they got to be so

413
00:16:52,110 --> 00:16:49,269

red is that they're covered with an

414
00:16:54,119 --> 00:16:52,120
organic sludge and this organic sludge

415
00:16:56,730 --> 00:16:54,129
which okay sludge is not a technical

416
00:16:59,670 --> 00:16:56,740
term this organic material might be

417
00:17:01,019 --> 00:16:59,680
similar to the material that we see for

418
00:17:03,420 --> 00:17:01,029
example on Titan that's been

419
00:17:07,199 --> 00:17:03,430
characterized as Titan Solon's and it

420
00:17:09,779 --> 00:17:07,209
might be made in interesting chemical

421
00:17:11,850 --> 00:17:09,789
ways you might for example bombard Isis

422
00:17:15,179 --> 00:17:11,860
particularly methane ice because it has

423
00:17:19,199 --> 00:17:15,189
carbon with ultraviolet or charged

424
00:17:21,569 --> 00:17:19,209
particles from the Sun and create these

425
00:17:24,329 --> 00:17:21,579
complex organics on the surfaces of

426
00:17:26,549 --> 00:17:24,339
these objects and so what scott intends

427
00:17:28,710 --> 00:17:26,559
to do is probe the distribution of

428
00:17:30,690 --> 00:17:28,720
colors in the outer solar system along

429
00:17:33,480 --> 00:17:30,700
with what the ISIS are that are actually

430
00:17:36,149 --> 00:17:33,490
present on the surfaces of these bodies

431
00:17:39,130 --> 00:17:36,159
to try to understand out of what Isis if

432
00:17:41,680 --> 00:17:39,140
in fact it is Isis you make

433
00:17:44,830 --> 00:17:41,690
this ultra red material that we observe

434
00:17:47,290 --> 00:17:44,840
we think to be organic rich and that

435
00:17:49,720 --> 00:17:47,300
ties in very nicely to what I try to do

436
00:17:52,960 --> 00:17:49,730
around discs around other stars where I

437
00:17:55,810 --> 00:17:52,970
try to understand what their colors tell

438
00:17:58,240 --> 00:17:55,820

us about their compositions and so here

439
00:18:00,730 --> 00:17:58,250
is shown on the right a number of

440
00:18:03,280 --> 00:18:00,740
different discs around stars so six of

441
00:18:04,690 --> 00:18:03,290
them that have different colors and in

442
00:18:07,780 --> 00:18:04,700
black is the one that I showed you

443
00:18:10,050 --> 00:18:07,790
earlier actually HR 47 96 and that's

444
00:18:13,540 --> 00:18:10,060
also what's shown on the left and black

445
00:18:15,580 --> 00:18:13,550
so that particular disc has a color

446
00:18:18,550 --> 00:18:15,590
which is very similar to the color of

447
00:18:20,830 --> 00:18:18,560
red outer solar system objects and shown

448
00:18:22,750 --> 00:18:20,840
in red / plotted with it is a centaur

449
00:18:26,170 --> 00:18:22,760
which is basically a Kuiper belt object

450
00:18:29,020 --> 00:18:26,180
named pholis so the similarity and color

451
00:18:32,110 --> 00:18:29,030
that we see between some of these red XO

452
00:18:34,300 --> 00:18:32,120
solar discs and the red colors that we

453
00:18:36,520 --> 00:18:34,310
see in the bodies in the outer solar

454
00:18:38,890 --> 00:18:36,530
system we think that the same

455
00:18:41,080 --> 00:18:38,900
Astrophysical planetary processes are at

456
00:18:43,240 --> 00:18:41,090
work in both kinds of systems and so

457
00:18:45,730 --> 00:18:43,250
we'd like to make the analogy from these

458
00:18:48,760 --> 00:18:45,740
red organic-rich objects in our system

459
00:18:51,610 --> 00:18:48,770
to the dust and bodies and other systems

460
00:18:54,190 --> 00:18:51,620
as also being red and organic rich and

461
00:18:57,250 --> 00:18:54,200
so Scott's work on the solar system will

462
00:18:59,230 --> 00:18:57,260
continue to inform what we can say about

463
00:19:01,480 --> 00:18:59,240

the composition of the material around

464
00:19:03,910 --> 00:19:01,490
other discs as I try to ask the question

465
00:19:06,880 --> 00:19:03,920
how many other planetary systems were

466
00:19:09,250 --> 00:19:06,890
capable of forming habitable planets and

467
00:19:13,660 --> 00:19:09,260
and seeding them with the carbon that

468
00:19:16,150 --> 00:19:13,670
was necessary for life so in that vein

469
00:19:18,160 --> 00:19:16,160
it is small bodies that bring the

470
00:19:20,530 --> 00:19:18,170
volatile xand organics that are

471
00:19:24,400 --> 00:19:20,540
interesting for life to young planets

472
00:19:26,620 --> 00:19:24,410
and a major thrust of our astrobiology

473
00:19:29,470 --> 00:19:26,630
group is to actually investigate these

474
00:19:31,810 --> 00:19:29,480
kinds of materials in situ so we can do

475
00:19:33,760 --> 00:19:31,820
these remote sensing observations and we

476
00:19:35,080 --> 00:19:33,770
can look at outer solar system bodies we

477
00:19:36,640 --> 00:19:35,090
can look at other discs but there's

478
00:19:38,890 --> 00:19:36,650
nothing like actually looking at the

479
00:19:41,110 --> 00:19:38,900
organics in your laboratory and trying

480
00:19:43,870 --> 00:19:41,120
to figure out how they came to be as

481
00:19:45,760 --> 00:19:43,880
they are so there's a lot of

482
00:19:47,590 --> 00:19:45,770
state-of-the-art instrumentation that's

483
00:19:50,269 --> 00:19:47,600
being brought to bear on the problem of

484
00:19:52,700 --> 00:19:50,279
meteoritic and commentary organics

485
00:19:54,739 --> 00:19:52,710
both at the Carnegie Institution and at

486
00:19:57,459 --> 00:19:54,749
the institutions of our co investigators

487
00:20:01,310 --> 00:19:57,469
so this is a slide from Rhonda Stroud

488
00:20:03,799 --> 00:20:01,320

showing an insta to a picture of

489
00:20:06,259 --> 00:20:03,809
organics in a meteorite and that's

490
00:20:08,269 --> 00:20:06,269
what's on the left here and it turns out

491
00:20:10,549 --> 00:20:08,279
that one of the mysteries of organic

492
00:20:12,709 --> 00:20:10,559
matter and meteorites is why much of it

493
00:20:15,879 --> 00:20:12,719
is found in these little nano globules

494
00:20:18,680 --> 00:20:15,889
these tiny isolated hollow spheres and

495
00:20:20,629 --> 00:20:18,690
presumably that unusual structure for

496
00:20:23,719 --> 00:20:20,639
the organics has something to say about

497
00:20:26,329 --> 00:20:23,729
how the organics were formed in the

498
00:20:29,479 --> 00:20:26,339
meteorite parent body but it's only by

499
00:20:32,899 --> 00:20:29,489
studying the organics in situ that you

500
00:20:34,609 --> 00:20:32,909
can really be sure that the shapes and

501
00:20:36,769 --> 00:20:34,619
nano scales that you're observing

502
00:20:38,989 --> 00:20:36,779
actually reflect what the parent body

503
00:20:40,609 --> 00:20:38,999
looks like and not some processing that

504
00:20:42,799 --> 00:20:40,619
happens in the laboratory afterwards

505
00:20:44,690 --> 00:20:42,809
although on the right is isolated

506
00:20:47,509 --> 00:20:44,700
organic material which does in fact

507
00:20:50,180 --> 00:20:47,519
still show one of these globules so the

508
00:20:52,549 --> 00:20:50,190
question is this organic material and

509
00:20:54,379 --> 00:20:52,559
meteorites it is insoluble organic

510
00:20:55,969 --> 00:20:54,389
matter which makes seventy percent or

511
00:20:58,999 --> 00:20:55,979
even close to a hundred percent of the

512
00:21:00,769 --> 00:20:59,009
organic material in meteorites where did

513
00:21:05,869 --> 00:21:00,779

it come from what is it and how did it

514
00:21:08,479 --> 00:21:05,879
get to its present form so a number of

515
00:21:11,859 --> 00:21:08,489
different analytical methods are being

516
00:21:14,570 --> 00:21:11,869
brought to bear on these questions and

517
00:21:16,879 --> 00:21:14,580
in the next slide I'm going to show you

518
00:21:19,579 --> 00:21:16,889
how a couple of them interrelate and

519
00:21:23,180 --> 00:21:19,589
that is looking at the isotopic and

520
00:21:26,299 --> 00:21:23,190
compositional composition of meteoritic

521
00:21:29,749 --> 00:21:26,309
organic matter institue so shown in the

522
00:21:32,629 --> 00:21:29,759
color on this slide is a nano Simms

523
00:21:35,450 --> 00:21:32,639
analysis of the isotopic composition of

524
00:21:37,849 --> 00:21:35,460
the organic material and you can see

525
00:21:39,829 --> 00:21:37,859
that rather than being isotopically

526
00:21:42,139 --> 00:21:39,839
homogeneous there are hot spots

527
00:21:44,209 --> 00:21:42,149
deuterium enriched hot spots nitrogen

528
00:21:47,029 --> 00:21:44,219
and rich nitrogen 15 and rich hot spots

529
00:21:48,700 --> 00:21:47,039
and so despite the fact that the

530
00:21:50,629 --> 00:21:48,710
organics have undergone considerable

531
00:21:52,690 --> 00:21:50,639
processing and their parent bodies

532
00:21:56,749 --> 00:21:52,700
somehow they've managed to maintain

533
00:21:59,539 --> 00:21:56,759
these very small scale inhomogeneities

534
00:22:00,829 --> 00:21:59,549
and that is another key question that

535
00:22:02,720 --> 00:22:00,839
the group here would like to answer

536
00:22:04,960 --> 00:22:02,730
about how the organics

537
00:22:08,840 --> 00:22:04,970
formed and more processed in meteorites

538
00:22:10,220 --> 00:22:08,850

so once people like Larry net lurves

539
00:22:13,669 --> 00:22:10,230
actually sitting behind me have gone

540
00:22:17,419 --> 00:22:13,679
ahead and analyzed the isotopic

541
00:22:19,880 --> 00:22:17,429
composition of the materials Rhonda

542
00:22:22,520 --> 00:22:19,890
Stroud can go in and actually extract

543
00:22:24,500 --> 00:22:22,530
little segments of the meteorite that

544
00:22:26,840 --> 00:22:24,510
are known to have these isotopic

545
00:22:28,850 --> 00:22:26,850
anomalies and so what you see in the

546
00:22:30,919 --> 00:22:28,860
grayscale underneath is electron

547
00:22:33,680 --> 00:22:30,929
microscope image showing the little

548
00:22:37,760 --> 00:22:33,690
segments that she can go and actually

549
00:22:39,650 --> 00:22:37,770
cut out with an ion beam and you can see

550
00:22:42,200 --> 00:22:39,660
that those little segments run right

551
00:22:46,310 --> 00:22:42,210
through those inhomogeneity is those hot

552
00:22:50,080 --> 00:22:46,320
spots in the isotopes so once those

553
00:22:53,150 --> 00:22:50,090
pieces are extracted then even more

554
00:22:56,510 --> 00:22:53,160
analytical tools can be brought to try

555
00:22:58,520 --> 00:22:56,520
to understand what that says about the

556
00:23:01,220 --> 00:22:58,530
kind of organics those hot spots are

557
00:23:04,159 --> 00:23:01,230
located in and so here you can see on

558
00:23:05,870 --> 00:23:04,169
the lower left an actual image of the

559
00:23:08,840 --> 00:23:05,880
area of that meteorite that's been

560
00:23:12,440 --> 00:23:08,850
extracted with the enriched hot spots

561
00:23:15,530 --> 00:23:12,450
along it and on the right x-ray spectra

562
00:23:17,930 --> 00:23:15,540
that show the molecular form of the

563
00:23:22,430 --> 00:23:17,940

organics that contain those hot spots

564
00:23:24,710 --> 00:23:22,440
and so together the idea is to use all

565
00:23:27,530 --> 00:23:24,720
of these techniques to ask how it is

566
00:23:29,930 --> 00:23:27,540
that you formed this insoluble organic

567
00:23:32,150 --> 00:23:29,940
matter how you incorporated these

568
00:23:33,470 --> 00:23:32,160
inhomogeneities into that matter and

569
00:23:35,930 --> 00:23:33,480
preserved them through whatever

570
00:23:41,030 --> 00:23:35,940
alteration was happening on the

571
00:23:43,400 --> 00:23:41,040
meteorite parent body so once you've

572
00:23:46,460 --> 00:23:43,410
done this you then still have to come up

573
00:23:49,100 --> 00:23:46,470
with an over-arching theory of the

574
00:23:51,770 --> 00:23:49,110
organic matter and it's pulling together

575
00:23:53,390 --> 00:23:51,780
all of these different results from the

576
00:23:55,130 --> 00:23:53,400
different analytical techniques that

577
00:23:57,490 --> 00:23:55,140
will really result in a comprehensive

578
00:24:00,830 --> 00:23:57,500
understanding of the organics and

579
00:24:02,419 --> 00:24:00,840
hopefully reveal how it originated so

580
00:24:05,539 --> 00:24:02,429
this slide shows some of the additional

581
00:24:08,600 --> 00:24:05,549
techniques that George is applying to

582
00:24:10,430 --> 00:24:08,610
the organics both those extracted from

583
00:24:14,030 --> 00:24:10,440
meteorites and from the veldt two

584
00:24:15,210 --> 00:24:14,040
samples and also reproducing them in the

585
00:24:16,919 --> 00:24:15,220
laboratory to an

586
00:24:19,710 --> 00:24:16,929
understand what the physical conditions

587
00:24:23,820 --> 00:24:19,720
are that may have produced the organics

588
00:24:26,789 --> 00:24:23,830

that are measured and so on the left for

589
00:24:29,580 --> 00:24:26,799
example you can see some results from

590
00:24:31,350 --> 00:24:29,590
typical meteorite insoluble organic

591
00:24:34,020 --> 00:24:31,360
matter compared to cometary matter and

592
00:24:35,850 --> 00:24:34,030
they bear many similarities in the

593
00:24:38,669 --> 00:24:35,860
middle you can see a two dimensional

594
00:24:41,070 --> 00:24:38,679
nuclear magnetic resonance imaging that

595
00:24:44,190 --> 00:24:41,080
shows the kind of structure that that

596
00:24:46,860 --> 00:24:44,200
organic matter takes and implies that it

597
00:24:50,430 --> 00:24:46,870
originated in simple sugars or in sugar

598
00:24:53,640 --> 00:24:50,440
like structures and in the laboratory

599
00:24:56,399 --> 00:24:53,650
George can take formaldehyde and through

600
00:24:57,659 --> 00:24:56,409
two sugars and do it under different

601
00:25:00,600 --> 00:24:57,669
temperatures and under aqueous

602
00:25:03,000 --> 00:25:00,610
conditions and produce a polymer an

603
00:25:06,360 --> 00:25:03,010
insoluble organic polymer which closely

604
00:25:08,279 --> 00:25:06,370
resembles in its spectrum the actual

605
00:25:10,950 --> 00:25:08,289
organic material that is found in

606
00:25:12,539 --> 00:25:10,960
meteorites and it appears that way not

607
00:25:15,779 --> 00:25:12,549
only in a spectrum and its composition

608
00:25:18,960 --> 00:25:15,789
but also in that image in terms of the

609
00:25:21,060 --> 00:25:18,970
ability to form the small spheres like

610
00:25:23,789 --> 00:25:21,070
what I showed you earlier and so there's

611
00:25:26,250 --> 00:25:23,799
the possibility that all of these

612
00:25:27,960 --> 00:25:26,260
organic solids originated from a set of

613
00:25:30,570 --> 00:25:27,970

chemistry starting from very simple

614
00:25:32,310 --> 00:25:30,580
precursors such as formaldehyde but

615
00:25:35,370 --> 00:25:32,320
that's a conclusion that remains to be

616
00:25:39,060 --> 00:25:35,380
proven and is a rest of George's work

617
00:25:41,760 --> 00:25:39,070
over the next few years so that wraps up

618
00:25:43,440 --> 00:25:41,770
the first two tasks of our astrobiology

619
00:25:45,360 --> 00:25:43,450
group so I'm going to turn it over to

620
00:25:52,200 --> 00:25:45,370
Steve shy right now to take off from

621
00:25:54,419 --> 00:25:52,210
there well I'm a new investigator you

622
00:25:56,340 --> 00:25:54,429
know to this team and I got involved

623
00:25:59,760 --> 00:25:56,350
because I have a lot of expertise in our

624
00:26:02,250 --> 00:25:59,770
key in geochemistry and in interaction

625
00:26:05,070 --> 00:26:02,260
between hydrothermal solutions and and

626
00:26:08,100 --> 00:26:05,080
ocean ridge systems and I've been really

627
00:26:09,899 --> 00:26:08,110
worried over the last 10 or 15 years on

628
00:26:11,490 --> 00:26:09,909
the formation of continents and of

629
00:26:15,419 --> 00:26:11,500
course forming a stable continental

630
00:26:16,890 --> 00:26:15,429
platform makes a platform for life

631
00:26:18,299 --> 00:26:16,900
that's in the photic zone and so all

632
00:26:20,190 --> 00:26:18,309
these processes happening the early

633
00:26:22,500 --> 00:26:20,200
Earth are very very key on when earth

634
00:26:24,960 --> 00:26:22,510
does become habitable what I'm going to

635
00:26:27,330 --> 00:26:24,970
talk about today are items three and

636
00:26:30,870 --> 00:26:27,340
four on this on this list here which is

637
00:26:33,660 --> 00:26:30,880
really having to do with the rocky

638
00:26:36,200 --> 00:26:33,670

planets and and what our investigative

639
00:26:38,970 --> 00:26:36,210
team is doing the first is on on

640
00:26:41,040 --> 00:26:38,980
volatiles the the carbon hydrogen oxygen

641
00:26:42,390 --> 00:26:41,050
and nitrogen volatile and planetary

642
00:26:44,790 --> 00:26:42,400
interiors and the second will be on

643
00:26:50,190 --> 00:26:44,800
primary carbon in Martian meteorites and

644
00:26:53,370 --> 00:26:50,200
terrestrial analog systems so let me

645
00:26:56,160 --> 00:26:53,380
start with our investigator John

646
00:26:57,750 --> 00:26:56,170
Chambers because this is where you'll

647
00:27:00,420 --> 00:26:57,760
see in the next slide here in a second

648
00:27:03,630 --> 00:27:00,430
where the original inventory of

649
00:27:06,110 --> 00:27:03,640
volatiles comes from John is doing

650
00:27:10,650 --> 00:27:06,120
simulations of giant planet formation

651
00:27:13,650 --> 00:27:10,660
that involve the considerations of

652
00:27:16,500 --> 00:27:13,660
migration of planetary cores inward and

653
00:27:19,080 --> 00:27:16,510
finds that when you when you involve

654
00:27:20,460 --> 00:27:19,090
migration in these calculations you can

655
00:27:23,160 --> 00:27:20,470
see in a plot here the most massive

656
00:27:26,460 --> 00:27:23,170
bodies versus the total dis mask you

657
00:27:29,610 --> 00:27:26,470
produce more habitable or more gas-rich

658
00:27:31,950 --> 00:27:29,620
of rocky planets that will allow you to

659
00:27:34,710 --> 00:27:31,960
you know to start with a perhaps a

660
00:27:37,230 --> 00:27:34,720
better inventory of volatiles and the

661
00:27:39,660 --> 00:27:37,240
question of whether we are inventory of

662
00:27:41,280 --> 00:27:39,670
allah tools is a primary one or volatile

663
00:27:43,170 --> 00:27:41,290

Zarda limited after is really the

664
00:27:45,090 --> 00:27:43,180
starting point for the study of

665
00:27:51,000 --> 00:27:45,100
planetary volatile so what we're

666
00:27:53,040 --> 00:27:51,010
concerned about next the next item that

667
00:27:56,670 --> 00:27:53,050
will talk about is a standalone project

668
00:27:58,920 --> 00:27:56,680
of the messenger project involving

669
00:28:00,210 --> 00:27:58,930
mercury and work that Sean Solomon's

670
00:28:02,970 --> 00:28:00,220
done over the years on Mars this

671
00:28:06,600 --> 00:28:02,980
involves investigator Shawn Solomon and

672
00:28:08,880 --> 00:28:06,610
Larry knit ler Larry again back to my

673
00:28:10,860 --> 00:28:08,890
left here I feel funny talking about it

674
00:28:13,320 --> 00:28:10,870
with him sitting behind me but the key

675
00:28:16,350 --> 00:28:13,330
question here is is when we look to the

676
00:28:19,080 --> 00:28:16,360
extreme limit of the smallest rocky body

677
00:28:23,220 --> 00:28:19,090
in our solar system how does that place

678
00:28:27,540 --> 00:28:23,230
a limit on the kind of conditions that

679
00:28:33,780 --> 00:28:27,550
we have on earth for for a volatile are

680
00:28:35,250 --> 00:28:33,790
volatile inventory well yeah so the key

681
00:28:37,500 --> 00:28:35,260
point about the messenger is it's a

682
00:28:40,029 --> 00:28:37,510
standalone project but it brings a great

683
00:28:43,330 --> 00:28:40,039
intellectual diversity in the thinking

684
00:28:44,950 --> 00:28:43,340
that helps us just add to the richness

685
00:28:47,440 --> 00:28:44,960
of the kind of discourse we have here

686
00:28:50,169 --> 00:28:47,450
within the team another important of

687
00:28:54,399 --> 00:28:50,179
thrust is is trying to put some limits

688
00:28:56,109 --> 00:28:54,409

on the solubility of water in in magmas

689
00:28:58,810 --> 00:28:56,119
and especially in lunar magma this has

690
00:29:01,060 --> 00:28:58,820
been the work of team member eric harry

691
00:29:02,889 --> 00:29:01,070
and his collaborator Alberto Sol from

692
00:29:04,869 --> 00:29:02,899
brown and they've come up with a very

693
00:29:08,590 --> 00:29:04,879
interesting result by doing iron probe

694
00:29:12,639 --> 00:29:08,600
work on lunar glasses and that result

695
00:29:14,649 --> 00:29:12,649
has given us a much theoretical or an

696
00:29:15,969 --> 00:29:14,659
empirical look at the water content of

697
00:29:18,460 --> 00:29:15,979
the moon and says that it's much higher

698
00:29:20,409 --> 00:29:18,470
than we originally thought and that's a

699
00:29:22,450 --> 00:29:20,419
very interesting result because during

700
00:29:25,239 --> 00:29:22,460
the JM packed means that we don't have

701
00:29:27,190 --> 00:29:25,249
to really dry out the silicate material

702
00:29:30,129 --> 00:29:27,200
that was splashed out of the Earth's

703
00:29:32,109 --> 00:29:30,139
mantle and form the moon and it also

704
00:29:35,049 --> 00:29:32,119
bears into what the final solubility

705
00:29:37,719 --> 00:29:35,059
limit of water might be in in these

706
00:29:43,119 --> 00:29:37,729
kinds of processes my own work is

707
00:29:45,969 --> 00:29:43,129
involved in looking at diamonds and and

708
00:29:48,969 --> 00:29:45,979
the importance of early deep-seated

709
00:29:51,729 --> 00:29:48,979
carbon on the earth and the next slide

710
00:29:54,909 --> 00:29:51,739
here we'll see some of the work we've

711
00:29:57,269 --> 00:29:54,919
done on continental crayons takes a

712
00:29:59,710 --> 00:29:57,279
while for these slides to refresh

713
00:30:01,330 --> 00:29:59,720

connell crayons on earth are the

714
00:30:03,279 --> 00:30:01,340
storehouse of the oldest rocks and you

715
00:30:06,369 --> 00:30:03,289
see in this particular slide here a

716
00:30:08,710 --> 00:30:06,379
cross-section through a crate on on the

717
00:30:10,899 --> 00:30:08,720
left from the bottom where we have a

718
00:30:13,539 --> 00:30:10,909
piece of mantle it's stuck to the crate

719
00:30:15,399 --> 00:30:13,549
on in his ancient and with kimberlite

720
00:30:18,580 --> 00:30:15,409
eruptions through this deep portion of

721
00:30:20,169 --> 00:30:18,590
the mantle we see diamonds a'kla joists

722
00:30:23,259 --> 00:30:20,179
and prototypes that are brought up in

723
00:30:24,700 --> 00:30:23,269
one you know one particular eruption any

724
00:30:26,259 --> 00:30:24,710
particular ruption and the Diamonds

725
00:30:28,359 --> 00:30:26,269
themselves the importance of those is

726
00:30:30,369 --> 00:30:28,369
those are the oldest deepest carbon

727
00:30:33,369 --> 00:30:30,379
bearing phases we can find in the oldest

728
00:30:36,190 --> 00:30:33,379
stages that will give us some idea of

729
00:30:40,269 --> 00:30:36,200
where carbon came from during early

730
00:30:42,210 --> 00:30:40,279
tectonic processes on earth now if you

731
00:30:45,369 --> 00:30:42,220
look at this cross-section through

732
00:30:47,139 --> 00:30:45,379
crotonic mantle what you see is the

733
00:30:50,240 --> 00:30:47,149
areas where we can get good information

734
00:30:53,840 --> 00:30:50,250
and diamonds are also being now record

735
00:30:55,520 --> 00:30:53,850
from below the lithosphere so we really

736
00:30:57,440 --> 00:30:55,530
have deep-seated carbon that we can

737
00:31:03,140 --> 00:30:57,450
study through a look at natural diamonds

738
00:31:05,630 --> 00:31:03,150

not only from a mouse here not only do

739
00:31:07,450 --> 00:31:05,640
we have diamonds that are that are part

740
00:31:10,370 --> 00:31:07,460
of the lithosphere here these ancient

741
00:31:11,810 --> 00:31:10,380
ancient root zones right here but we

742
00:31:13,760 --> 00:31:11,820
have doubt diamonds that come from the

743
00:31:15,500 --> 00:31:13,770
transition zone and represent deep

744
00:31:17,630 --> 00:31:15,510
mantle recycling into the transition

745
00:31:20,290 --> 00:31:17,640
zone and that's a very exciting new new

746
00:31:26,030 --> 00:31:20,300
find that we're going to be trying to

747
00:31:27,680 --> 00:31:26,040
capitalize on in the work diamonds are

748
00:31:30,890 --> 00:31:27,690
important because they span a great age

749
00:31:33,290 --> 00:31:30,900
range across the type of changes that

750
00:31:37,540 --> 00:31:33,300
we've seen on the earth and so in the

751
00:31:40,490 --> 00:31:37,550
next slide you'll see a plot here of

752
00:31:41,810 --> 00:31:40,500
diamond age ranges from different minds

753
00:31:44,270 --> 00:31:41,820
the mines are over here on the left

754
00:31:45,620 --> 00:31:44,280
these are various localities and then

755
00:31:47,870 --> 00:31:45,630
the age range of diamonds have been

756
00:31:49,790 --> 00:31:47,880
found from those particular mines are

757
00:31:50,930 --> 00:31:49,800
these black bars and you can see that

758
00:31:53,300 --> 00:31:50,940
there's quite a range from the

759
00:31:56,810 --> 00:31:53,310
proterozoic all the way through into the

760
00:31:59,240 --> 00:31:56,820
mezzo even to some cases the ER kyun and

761
00:32:01,430 --> 00:31:59,250
that not only spans the range of major

762
00:32:04,280 --> 00:32:01,440
crust formation on the earth but also

763
00:32:06,080 --> 00:32:04,290

spans the change in from reducing

764
00:32:08,630 --> 00:32:06,090
atmosphere on the earth to oxidizing

765
00:32:10,730 --> 00:32:08,640
atmosphere on the earth and so when we

766
00:32:12,800 --> 00:32:10,740
go back and try to reconstruct where

767
00:32:14,660 --> 00:32:12,810
these carbon bearing fluids came from we

768
00:32:16,460 --> 00:32:14,670
do have a chance to really look at a

769
00:32:21,200 --> 00:32:16,470
tremendous range in the geological

770
00:32:23,510 --> 00:32:21,210
evolution of our entire planet the way

771
00:32:25,490 --> 00:32:23,520
this is done is by determining the age

772
00:32:28,340 --> 00:32:25,500
through looking at mineral inclusions in

773
00:32:30,710 --> 00:32:28,350
diamonds and in the next slide you'll

774
00:32:32,030 --> 00:32:30,720
see some pictures of the types of

775
00:32:34,400 --> 00:32:32,040
inclusions I won't go into a lot of

776
00:32:36,170 --> 00:32:34,410
detail but there are two main types of

777
00:32:38,450 --> 00:32:36,180
inclusions silicate inclusions and

778
00:32:40,100 --> 00:32:38,460
sulphide inclusions and we can work on

779
00:32:41,480 --> 00:32:40,110
each one of these we've done a lot more

780
00:32:43,280 --> 00:32:41,490
work recently on the sulphide inclusions

781
00:32:45,350 --> 00:32:43,290
because we can analyze individual

782
00:32:46,730 --> 00:32:45,360
diamonds but one of the things we do is

783
00:32:48,770 --> 00:32:46,740
to not only get the age from the

784
00:32:50,990 --> 00:32:48,780
sulphide where we look at the carbon

785
00:32:53,260 --> 00:32:51,000
isotopic composition and the stable

786
00:32:55,610 --> 00:32:53,270
isotopic composition of the sulfur and

787
00:32:58,160 --> 00:32:55,620
from that we can try to determine

788
00:33:01,130 --> 00:32:58,170

whether the source of the carbon was

789
00:33:02,290 --> 00:33:01,140
biotic or abiotic and in some cases we

790
00:33:04,360 --> 00:33:02,300
can also look at the nitrous

791
00:33:06,880 --> 00:33:04,370
nice atopic composition of trace

792
00:33:09,240 --> 00:33:06,890
nitrogen that's in the diamond a really

793
00:33:11,770 --> 00:33:09,250
interesting result that was obtained by

794
00:33:14,950 --> 00:33:11,780
one of the team members James Farquhar

795
00:33:17,770 --> 00:33:14,960
was published in 2002 in science and in

796
00:33:20,500 --> 00:33:17,780
a diamond from araba something that was

797
00:33:23,140 --> 00:33:20,510
stored at 150 kilometers in lithosphere

798
00:33:25,600 --> 00:33:23,150
he discovered yes independent soul fries

799
00:33:30,160 --> 00:33:25,610
the topic composition differences from

800
00:33:32,980 --> 00:33:30,170
from the normal fractionation that can

801
00:33:36,730 --> 00:33:32,990
only have come from photolytic processes

802
00:33:39,160 --> 00:33:36,740
in india in the stratosphere before we

803
00:33:42,430 --> 00:33:39,170
had shielding oxygen to block those kind

804
00:33:44,470 --> 00:33:42,440
of isotopic change so that does this

805
00:33:47,260 --> 00:33:44,480
striking implication is that the carpets

806
00:33:49,380 --> 00:33:47,270
the sulfur from volcanic eruptions up

807
00:33:53,920 --> 00:33:49,390
into the stratosphere in the archaean

808
00:33:55,210 --> 00:33:53,930
was able to these eruptions produce

809
00:33:59,020 --> 00:33:55,220
sulfur that was able to have his

810
00:34:01,210 --> 00:33:59,030
isotopic composition changed that the

811
00:34:02,800 --> 00:34:01,220
sulfur was then brought down you know

812
00:34:04,930 --> 00:34:02,810
into sediments that were then subduction

813
00:34:06,730 --> 00:34:04,940

down in the lithosphere where they

814
00:34:08,919 --> 00:34:06,740
became part of diamond forming fluids so

815
00:34:11,320 --> 00:34:08,929
this is prima facie evidence that we

816
00:34:15,570 --> 00:34:11,330
have surface carbon as inclusions in

817
00:34:18,100 --> 00:34:15,580
diamonds now one of the nice things

818
00:34:20,370 --> 00:34:18,110
that's been added to the team is is a

819
00:34:23,680 --> 00:34:20,380
new by new investigator buren meeson and

820
00:34:28,510 --> 00:34:23,690
buren Mason's expertise the next slide

821
00:34:31,000 --> 00:34:28,520
here is in studying the solubility and

822
00:34:32,919 --> 00:34:31,010
solution mechanisms of various volatile

823
00:34:35,490 --> 00:34:32,929
species depending on what the redox

824
00:34:38,409 --> 00:34:35,500
state of this particular experimental

825
00:34:41,860 --> 00:34:38,419
procedures are and so here he's got some

826
00:34:43,390 --> 00:34:41,870
experimental studies of volatiles in

827
00:34:45,400 --> 00:34:43,400
high-pressure silicate melts an

828
00:34:46,990 --> 00:34:45,410
interesting thing on the left here as

829
00:34:52,470 --> 00:34:47,000
you can see at different pressures here

830
00:34:55,210 --> 00:34:52,480
pressure is increasing with a bunch of

831
00:34:57,610 --> 00:34:55,220
spectral lines here raman shift raman

832
00:34:58,840 --> 00:34:57,620
spectra the higher pressure lines are at

833
00:35:00,880 --> 00:34:58,850
the top and the lower pressure on the

834
00:35:03,610 --> 00:35:00,890
bottom you can see a change in the

835
00:35:07,570 --> 00:35:03,620
absolute concentration or the relative

836
00:35:11,690 --> 00:35:07,580
concentration of methane hydroxyl

837
00:35:14,060 --> 00:35:11,700
hydrogen and and other species

838
00:35:16,160 --> 00:35:14,070

and what's interesting about the work is

839
00:35:19,099 --> 00:35:16,170
that not only is he able to look at the

840
00:35:21,620 --> 00:35:19,109
change in the very the composition of

841
00:35:22,960 --> 00:35:21,630
the volatile volatile species but

842
00:35:25,400 --> 00:35:22,970
there's also a carbon isotopic

843
00:35:29,060 --> 00:35:25,410
composition change it seems to be coming

844
00:35:32,930 --> 00:35:29,070
out depending on the type of oxidation

845
00:35:34,310 --> 00:35:32,940
state and the type of composition and

846
00:35:37,790 --> 00:35:34,320
structure of the melt so over here on

847
00:35:41,240 --> 00:35:37,800
the right you can see a bill c-13 change

848
00:35:43,780 --> 00:35:41,250
as you change the non bridging oxygen to

849
00:35:46,460 --> 00:35:43,790
silicon ratio or the melt composition

850
00:35:49,550 --> 00:35:46,470
yarn is also working in nitrogen and the

851
00:35:51,410 --> 00:35:49,560
different oxygen fugacity and what you

852
00:35:54,140 --> 00:35:51,420
see in the next slide here is again

853
00:35:56,990 --> 00:35:54,150
aramis spectra on the Left showing the

854
00:36:01,520 --> 00:35:57,000
range of species ranging from ammonia to

855
00:36:06,829 --> 00:36:01,530
two hydroxyl to two nitrogen dimers and

856
00:36:09,079 --> 00:36:06,839
and that the bulk composition of those

857
00:36:11,540 --> 00:36:09,089
nitrogen species changes with with

858
00:36:12,980 --> 00:36:11,550
oxygen fugacity so it is the solubility

859
00:36:14,569 --> 00:36:12,990
limit for nitrogen and there's a

860
00:36:18,140 --> 00:36:14,579
tremendous change depending on oxygen

861
00:36:19,819 --> 00:36:18,150
fugacity in all cases nitrogen increases

862
00:36:22,069 --> 00:36:19,829
with increasing pressure but the

863
00:36:23,660 --> 00:36:22,079

solubility goes way up at reducing

864
00:36:25,010 --> 00:36:23,670
conditions so these are some of the

865
00:36:26,930 --> 00:36:25,020
fundamental questions that this

866
00:36:28,910 --> 00:36:26,940
experimental approach will help us get

867
00:36:30,800 --> 00:36:28,920
to to try to understand how volatile zar

868
00:36:34,010 --> 00:36:30,810
stored and how they cycle through the

869
00:36:36,260 --> 00:36:34,020
earth another new team member alex

870
00:36:38,359 --> 00:36:36,270
Goncharov is taking this to extreme

871
00:36:42,050 --> 00:36:38,369
conditions and here we have some

872
00:36:44,500 --> 00:36:42,060
examples of how he's looking at it more

873
00:36:46,819 --> 00:36:44,510
extreme conditions not so much that the

874
00:36:48,319 --> 00:36:46,829
type of things Bjorn was looking at

875
00:36:51,170 --> 00:36:48,329
where we looking at the actual

876
00:36:53,450 --> 00:36:51,180
speciation and Mel structure but really

877
00:36:55,579 --> 00:36:53,460
looking at what kind of species exist at

878
00:36:57,650 --> 00:36:55,589
extreme conditions and also modeling it

879
00:37:01,819 --> 00:36:57,660
with some molecular dynamic simulations

880
00:37:06,970 --> 00:37:01,829
which you see on the right and finally

881
00:37:10,069 --> 00:37:06,980
we get to the the work of Andrew Steele

882
00:37:12,700 --> 00:37:10,079
long-term na i-team investigator here

883
00:37:16,370 --> 00:37:12,710
and on the top of this of this series of

884
00:37:19,120 --> 00:37:16,380
photomicrographs you see here are some

885
00:37:21,680 --> 00:37:19,130
these top three panels a B and C are

886
00:37:24,109 --> 00:37:21,690
natural samples of a prototype from

887
00:37:25,070 --> 00:37:24,119
Svalbard of the backyard region and the

888
00:37:28,070 --> 00:37:25,080

bottom two

889
00:37:30,620 --> 00:37:28,080
those are two Martian meteorites and

890
00:37:33,830 --> 00:37:30,630
what what he's doing is trying to look

891
00:37:35,840 --> 00:37:33,840
at the storage of macromolecular carbon

892
00:37:38,660 --> 00:37:35,850
and the hosting minerals from a coma

893
00:37:42,410 --> 00:37:38,670
macromolecular carbon and try to from

894
00:37:44,000 --> 00:37:42,420
the terrestrial localities look at what

895
00:37:47,890 --> 00:37:44,010
the analog conditions might be for the

896
00:37:51,140 --> 00:37:47,900
storage and and how this macromolecular

897
00:37:55,010 --> 00:37:51,150
carbon is stored in the various minerals

898
00:37:57,080 --> 00:37:55,020
in these particular meteorites and with

899
00:38:00,860 --> 00:37:57,090
that I'll turn over to team member

900
00:38:02,360 --> 00:38:00,870
Marilyn Fogle George okay George I'm

901
00:38:03,740 --> 00:38:02,370
sorry well actually I thought you were

902
00:38:05,090 --> 00:38:03,750
gonna cover this but I can understand

903
00:38:07,310 --> 00:38:05,100
why you don't want to so I'll be very

904
00:38:09,200 --> 00:38:07,320
brief oh okay no worries no worries so

905
00:38:12,830 --> 00:38:09,210
uh turns out all of this these studies

906
00:38:14,960 --> 00:38:12,840
of especially the delivery of the

907
00:38:17,450 --> 00:38:14,970
storage of and the release of follicles

908
00:38:19,400 --> 00:38:17,460
it needs to say beeston two fundamental

909
00:38:21,290 --> 00:38:19,410
issues relate to potentially a

910
00:38:23,560 --> 00:38:21,300
connection between geochemical evolution

911
00:38:26,240 --> 00:38:23,570
planet the emergence and origins of life

912
00:38:28,670 --> 00:38:26,250
this is a smaller task in a sense it's

913
00:38:30,170 --> 00:38:28,680

myself Bob Hazen in the Beatrice virgin

914
00:38:33,020 --> 00:38:30,180
ski in Johns Hopkins University of the

915
00:38:34,610 --> 00:38:33,030
new co I my interest has long been and

916
00:38:36,860 --> 00:38:34,620
continues to be the extent to which

917
00:38:38,840 --> 00:38:36,870
mantle derived carbon and perhaps

918
00:38:41,000 --> 00:38:38,850
hydrogen either directly or through

919
00:38:42,410 --> 00:38:41,010
serpentinization could be used in the

920
00:38:45,290 --> 00:38:42,420
presence of various transition metal

921
00:38:47,360 --> 00:38:45,300
sulfide catalysts to drive a complex

922
00:38:49,040 --> 00:38:47,370
reaction networking so these are serious

923
00:38:50,270 --> 00:38:49,050
experiments that we do under various

924
00:38:52,550 --> 00:38:50,280
temperature pressures include

925
00:38:54,350 --> 00:38:52,560
compositions with appropriate catalysts

926
00:38:57,320 --> 00:38:54,360
that we trusted Lee try to follow the

927
00:38:58,880 --> 00:38:57,330
chemistry if you will of course this is

928
00:39:01,370 --> 00:38:58,890
just a chemical reaction Network it

929
00:39:04,040 --> 00:39:01,380
works under fairly dilute conditions so

930
00:39:05,630 --> 00:39:04,050
demetrice for jet ski and Bob Hazen have

931
00:39:07,280 --> 00:39:05,640
been tensely interested in how mineral

932
00:39:10,910 --> 00:39:07,290
surfaces may play a fundamental role in

933
00:39:13,250 --> 00:39:10,920
selecting out of a relatively dilute if

934
00:39:17,390 --> 00:39:13,260
you will a suit of complex calm

935
00:39:18,920 --> 00:39:17,400
compounds and not just select them but

936
00:39:20,540 --> 00:39:18,930
maybe perhaps even allow them to do

937
00:39:22,310 --> 00:39:20,550
things so in this slide is finally

938
00:39:24,950 --> 00:39:22,320

popped up you're looking at a very

939
00:39:27,440 --> 00:39:24,960
recent study came out of Dimitris work

940
00:39:29,060 --> 00:39:27,450
with actually two any i funded postdocs

941
00:39:32,480 --> 00:39:29,070
looking at glutamate attachment on

942
00:39:34,820 --> 00:39:32,490
rutile Demetrius burtynsky is the expert

943
00:39:36,690 --> 00:39:34,830
on surface thermodynamics surface

944
00:39:39,180 --> 00:39:36,700
chemical thermodynamics

945
00:39:41,160 --> 00:39:39,190
and he is come up with some very

946
00:39:43,380 --> 00:39:41,170
sophisticated models to understand how

947
00:39:46,079 --> 00:39:43,390
various organic compounds would like

948
00:39:48,599 --> 00:39:46,089
eight to two surfaces based on ph and

949
00:39:50,790 --> 00:39:48,609
electric double layer effects and on the

950
00:39:52,920 --> 00:39:50,800
left you see experimental results that

951
00:39:54,960 --> 00:39:52,930
his two postdocs have performed doing

952
00:39:57,240 --> 00:39:54,970
very careful tie take titration studies

953
00:39:59,099 --> 00:39:57,250
and you see and without it going to any

954
00:40:00,930 --> 00:39:59,109
detailed in fact Dmitri it looks like

955
00:40:02,579 --> 00:40:00,940
Dimitri's getting this right so this is

956
00:40:04,440 --> 00:40:02,589
just the beginning of a five-year

957
00:40:08,430 --> 00:40:04,450
project to sort out some very very

958
00:40:10,020 --> 00:40:08,440
complex phenomena on mineral surfaces so

959
00:40:12,960 --> 00:40:10,030
with that I'm going to hand it over to

960
00:40:16,579 --> 00:40:12,970
test five and six Marilyn Fogle and I

961
00:40:20,400 --> 00:40:16,589
will get this thing to go find Marilyn

962
00:40:25,099 --> 00:40:20,410
here she comes Larry there's Marilyn

963
00:40:30,720 --> 00:40:25,109

yeah get you in here there's a lot Tuffy

964
00:40:34,109 --> 00:40:30,730
yeah I'll get you a depends good

965
00:40:38,069 --> 00:40:34,119
afternoon one of the I think the

966
00:40:40,500 --> 00:40:38,079
strength of our biology program here at

967
00:40:48,900 --> 00:40:40,510
the crazy is that they have a very close

968
00:40:54,890 --> 00:40:48,910
association organic studies that part

969
00:40:57,770 --> 00:40:54,900
derived from Sun biological means and

970
00:41:00,990 --> 00:40:57,780
one of the major thrust that we've had

971
00:41:04,290 --> 00:41:01,000
at least for the past five years is to

972
00:41:06,599 --> 00:41:04,300
be able to distinguish biologically

973
00:41:09,260 --> 00:41:06,609
derived organic matter with a

974
00:41:12,480 --> 00:41:09,270
biologically derived organic matter and

975
00:41:15,210 --> 00:41:12,490
most of us on this team who are

976
00:41:18,630 --> 00:41:15,220
considered on the biology and also

977
00:41:22,500 --> 00:41:18,640
participate very heavily with with Steve

978
00:41:25,890 --> 00:41:22,510
and with George and understanding the

979
00:41:28,760 --> 00:41:25,900
properties and characteristics of

980
00:41:31,550 --> 00:41:28,770
organic matter in terms of isotopes and

981
00:41:36,120 --> 00:41:31,560
composition and how they look under

982
00:41:39,510 --> 00:41:36,130
microscopic methods so we begin the

983
00:41:44,220 --> 00:41:39,520
strict biology session by studying life

984
00:41:46,650 --> 00:41:44,230
life at extremes and for the third time

985
00:41:48,780 --> 00:41:46,660
we are working with our long-term

986
00:41:49,530 --> 00:41:48,790
colleague from the University of

987
00:41:52,200 --> 00:41:49,540
Washington

988
00:41:58,170 --> 00:41:52,210

who is John Burroughs probably everybody

989
00:42:01,140 --> 00:41:58,180
knows knows John and the the studies

990
00:42:03,900 --> 00:42:01,150
that he's particularly interested in in

991
00:42:06,620 --> 00:42:03,910
completing for this project are looking

992
00:42:09,890 --> 00:42:06,630
at in assessing the importance of

993
00:42:16,650 --> 00:42:09,900
hydrogen supported microbial biofilms

994
00:42:19,790 --> 00:42:16,660
John has been studying biofilms and

995
00:42:22,490 --> 00:42:19,800
looking at hydrogen growing

996
00:42:25,340 --> 00:42:22,500
microorganisms for a number of years and

997
00:42:27,990 --> 00:42:25,350
if you know John he always has some very

998
00:42:31,650 --> 00:42:28,000
interesting questions that that he'd

999
00:42:35,580 --> 00:42:31,660
like to answer and the main one he's

1000
00:42:37,290 --> 00:42:35,590
going to address in this proposal is you

1001
00:42:39,390 --> 00:42:37,300
can see on their wife biofilms are

1002
00:42:43,050 --> 00:42:39,400
important to the origin and evolution of

1003
00:42:47,160 --> 00:42:43,060
life and in this question here he's

1004
00:42:50,100 --> 00:42:47,170
thinking of looking at what he calls pre

1005
00:42:53,430 --> 00:42:50,110
cells and the Earth's earliest network

1006
00:42:55,800 --> 00:42:53,440
and at the moment he's very enamored in

1007
00:42:58,980 --> 00:42:55,810
stunning horizontal gene transfer the

1008
00:43:03,330 --> 00:42:58,990
transfer of genetic material from one

1009
00:43:06,060 --> 00:43:03,340
species to another species and as part

1010
00:43:10,290 --> 00:43:06,070
of this work there are two different

1011
00:43:13,050 --> 00:43:10,300
kinds of projects on here one is with a

1012
00:43:15,500 --> 00:43:13,060
new student Billy brazelton who is a

1013
00:43:18,390 --> 00:43:15,510

student at the University of Washington

1014
00:43:20,640 --> 00:43:18,400
who will be stunning the lost city

1015
00:43:25,410 --> 00:43:20,650
carbonate chimneys and we'll go into the

1016
00:43:27,690 --> 00:43:25,420
the differences there and a former

1017
00:43:30,570 --> 00:43:27,700
student mad shrink who was also a

1018
00:43:33,510 --> 00:43:30,580
postdoc at the at the geophysical lab

1019
00:43:37,110 --> 00:43:33,520
Heron is now a colleague at East

1020
00:43:39,470 --> 00:43:37,120
Carolina University Matt will be looking

1021
00:43:43,830 --> 00:43:39,480
at the comparative structures and

1022
00:43:47,370 --> 00:43:43,840
sulfide chimneys so if you look at the

1023
00:43:51,750 --> 00:43:47,380
at the next graphic that comes up here

1024
00:43:55,200 --> 00:43:51,760
and the very interesting comparison that

1025
00:43:59,350 --> 00:43:55,210
we see is between on the top panel over

1026
00:44:03,180 --> 00:43:59,360
there stunning hydrothermal vents in

1027
00:44:05,830 --> 00:44:03,190
magma hosted systems where the ph is low

1028
00:44:08,770 --> 00:44:05,840
temperatures are fairly high extremely

1029
00:44:11,620 --> 00:44:08,780
high of its F to 400 degrees there are

1030
00:44:14,710 --> 00:44:11,630
ample carbon sources catalytic minerals

1031
00:44:16,920 --> 00:44:14,720
and I would have to say that that sort

1032
00:44:19,630 --> 00:44:16,930
of environment is something that

1033
00:44:22,960 --> 00:44:19,640
together with the microbiologist

1034
00:44:26,230 --> 00:44:22,970
dovetails exactly that work with george

1035
00:44:29,560 --> 00:44:26,240
cody has done over the years george and

1036
00:44:32,320 --> 00:44:29,570
his colleagues down below on the on the

1037
00:44:36,070 --> 00:44:32,330
lower panel there is the work on the

1038
00:44:39,070 --> 00:44:36,080

pretty tight hosted hydrothermal systems

1039
00:44:42,580 --> 00:44:39,080
from the lost city and you can see their

1040
00:44:46,420 --> 00:44:42,590
temperatures or more moderate ph values

1041
00:44:49,750 --> 00:44:46,430
are very high this work dovetails with

1042
00:44:54,010 --> 00:44:49,760
some earlier work we did on the last can

1043
00:44:57,790 --> 00:44:54,020
at the Cedars microbial system out in

1044
00:45:01,540 --> 00:44:57,800
California with penny Morel and in

1045
00:45:03,340 --> 00:45:01,550
general what our goal here is to compare

1046
00:45:06,900 --> 00:45:03,350
the two different types of hydrothermal

1047
00:45:08,920 --> 00:45:06,910
systems and assess the different type of

1048
00:45:11,710 --> 00:45:08,930
microorganisms that are found in there

1049
00:45:13,870 --> 00:45:11,720
what you see on this next slide is it

1050
00:45:16,660 --> 00:45:13,880
something that on the upper right hand

1051
00:45:21,160 --> 00:45:16,670
corner over there there's a great

1052
00:45:22,960 --> 00:45:21,170
picture of it has John points out that

1053
00:45:26,680 --> 00:45:22,970
greater than eighty percent of those

1054
00:45:31,060 --> 00:45:26,690
cells or a single species misano sarsen

1055
00:45:33,460 --> 00:45:31,070
alleys and what John is being getting a

1056
00:45:37,770 --> 00:45:33,470
handle on here is that within the

1057
00:45:40,720 --> 00:45:37,780
biofilm there that individual cells are

1058
00:45:43,630 --> 00:45:40,730
conducting different and very

1059
00:45:45,850 --> 00:45:43,640
specifically segregated types of

1060
00:45:50,230 --> 00:45:45,860
metabolism showing the importance of a

1061
00:45:54,760 --> 00:45:50,240
biofilm rather than single cultures down

1062
00:45:58,690 --> 00:45:54,770
on the lower left-hand you see a diagram

1063
00:46:01,800 --> 00:45:58,700

of the number of operational taxonomic

1064
00:46:06,070 --> 00:46:01,810
units that's what OT use our and

1065
00:46:09,250 --> 00:46:06,080
basically on the one scale you can see

1066
00:46:11,050 --> 00:46:09,260
that the preponderance of organisms are

1067
00:46:11,849 --> 00:46:11,060
the one species but if you trace that

1068
00:46:14,789 --> 00:46:11,859
out

1069
00:46:17,999 --> 00:46:14,799
you can see that diversity and rare

1070
00:46:21,120 --> 00:46:18,009
cells are are something that is as a

1071
00:46:25,049 --> 00:46:21,130
feature of these of these kinds of

1072
00:46:27,210 --> 00:46:25,059
ecosystems and I think this side came

1073
00:46:33,210 --> 00:46:27,220
from also a collaboration with Julie

1074
00:46:36,089 --> 00:46:33,220
Huber who is now at MBL in what soul she

1075
00:46:39,479 --> 00:46:36,099
was a student supported by the NAI

1076
00:46:42,809 --> 00:46:39,489
during can one I believe and also an nai

1077
00:46:46,019 --> 00:46:42,819
postdoc throughout this time Matt shrink

1078
00:46:48,839 --> 00:46:46,029
is continuing to work on biofilms and

1079
00:46:51,890 --> 00:46:48,849
mineral catalytic systems what you can

1080
00:46:55,799 --> 00:46:51,900
see over here is he's going to compare

1081
00:47:00,059 --> 00:46:55,809
laboratory cultures with biofilms that

1082
00:47:02,630 --> 00:47:00,069
were formed Institute on on vents he's

1083
00:47:06,749 --> 00:47:02,640
been the last couple years doing

1084
00:47:08,999 --> 00:47:06,759
experiments and trying out novel culture

1085
00:47:11,819 --> 00:47:09,009
mechanisms as you know some of the

1086
00:47:16,229 --> 00:47:11,829
challenge in the microbiology field is

1087
00:47:19,370 --> 00:47:16,239
that you're only able to actually Colt a

1088
00:47:21,930 --> 00:47:19,380

culture I think it's less than 1% of the

1089
00:47:25,440 --> 00:47:21,940
organisms that potentially grow within

1090
00:47:28,319 --> 00:47:25,450
any one environment and this is some

1091
00:47:31,140 --> 00:47:28,329
work from volcano Sicily where he's

1092
00:47:34,799 --> 00:47:31,150
collaborating with Yan almond and other

1093
00:47:37,589 --> 00:47:34,809
scientists who are also part of Nai and

1094
00:47:40,829 --> 00:47:37,599
I should note that Matt is now at East

1095
00:47:43,200 --> 00:47:40,839
Carolina where our former astrobiology

1096
00:47:47,420 --> 00:47:43,210
Chief John Rummel is now the director of

1097
00:47:50,279 --> 00:47:47,430
that and we would imagine that this is a

1098
00:47:52,650 --> 00:47:50,289
school in which he hopes to attract a

1099
00:47:57,870 --> 00:47:52,660
lot of undergraduates to the field of

1100
00:48:03,170 --> 00:47:57,880
astrobiology the other kind of extreme

1101
00:48:07,440 --> 00:48:03,180
environments we're studying is the the

1102
00:48:10,859 --> 00:48:07,450
effect of pressure on on microbial

1103
00:48:12,720 --> 00:48:10,869
growth and you can see on the right hand

1104
00:48:14,849 --> 00:48:12,730
side there and the cells that were

1105
00:48:18,059 --> 00:48:14,859
subjected this is e coli that were

1106
00:48:21,509 --> 00:48:18,069
subjected to greater than a hundred mega

1107
00:48:23,430 --> 00:48:21,519
pascals of pressure probably going up to

1108
00:48:25,410 --> 00:48:23,440
well you can see up to four hundred mega

1109
00:48:28,200 --> 00:48:25,420
pascals here which is at the

1110
00:48:31,890 --> 00:48:28,210
bit of our hydro thermal reaction

1111
00:48:33,870 --> 00:48:31,900
vessels that we have here and what you

1112
00:48:37,799 --> 00:48:33,880
can see on the left-hand panel is that

1113
00:48:40,130 --> 00:48:37,809

while most of the e.coli is killed at

1114
00:48:43,559 --> 00:48:40,140
these extremely high pressures

1115
00:48:46,620 --> 00:48:43,569
experiments with halo bacterium a salt

1116
00:48:49,920 --> 00:48:46,630
loving bacteria by Adrian Kish who is a

1117
00:48:51,750 --> 00:48:49,930
new post doc here at the laboratory show

1118
00:48:55,410 --> 00:48:51,760
that as it put on they're not all

1119
00:48:58,230 --> 00:48:55,420
microorganisms alike adrian is working

1120
00:49:02,000 --> 00:48:58,240
on molecular biological methods for

1121
00:49:04,500 --> 00:49:02,010
determining what the the actual

1122
00:49:07,380 --> 00:49:04,510
biochemical underpinnings are for the

1123
00:49:10,049 --> 00:49:07,390
ability of Halo files to survive the

1124
00:49:13,380 --> 00:49:10,059
very high pressures and patrick griffin

1125
00:49:15,359 --> 00:49:13,390
who was possibly going to be a real

1126
00:49:17,970 --> 00:49:15,369
graduate student he's a half graduate

1127
00:49:20,789 --> 00:49:17,980
student right now at Johns Hopkins in

1128
00:49:23,010 --> 00:49:20,799
the fall is right now he's doing some

1129
00:49:27,390 --> 00:49:23,020
stable isotope experiments with the

1130
00:49:29,490 --> 00:49:27,400
hydrogen isotopes in my laboratory we

1131
00:49:33,120 --> 00:49:29,500
have a lot of fieldwork planned for this

1132
00:49:35,609 --> 00:49:33,130
team Adrian Kish microbiologist and

1133
00:49:38,730 --> 00:49:35,619
mahalo limoge Leo who is a also a

1134
00:49:41,190 --> 00:49:38,740
postdoc plan to go out to white sands

1135
00:49:45,630 --> 00:49:41,200
national monument where there is one of

1136
00:49:48,000 --> 00:49:45,640
the largest año en sulfate deposits out

1137
00:49:51,900 --> 00:49:48,010
there in terms of lake beds and

1138
00:49:55,200 --> 00:49:51,910

evaporites Adrian is the microbiologist

1139
00:49:58,049 --> 00:49:55,210
and mihaila as a budding microbiologist

1140
00:49:59,640 --> 00:49:58,059
geologist geochemists are going to go

1141
00:50:01,770 --> 00:49:59,650
out there together it's a very

1142
00:50:04,770 --> 00:50:01,780
interesting team they work with Andrew

1143
00:50:06,770 --> 00:50:04,780
Steele they're going to study the

1144
00:50:09,870 --> 00:50:06,780
geology put this in context with the

1145
00:50:14,220 --> 00:50:09,880
microbiology and bring back a number of

1146
00:50:17,760 --> 00:50:14,230
samples to work on both through a Mars

1147
00:50:21,390 --> 00:50:17,770
analog perspective and also of microbial

1148
00:50:23,490 --> 00:50:21,400
biogeochemistry some other work that has

1149
00:50:26,880 --> 00:50:23,500
been ongoing here in the laboratory is

1150
00:50:30,420 --> 00:50:26,890
the amazed expedition Arctic Mars analog

1151
00:50:32,849 --> 00:50:30,430
starboard expedition this is work I

1152
00:50:35,700 --> 00:50:32,859
chose this picture here you can see the

1153
00:50:39,180 --> 00:50:35,710
research vessel that we use and this was

1154
00:50:41,160 --> 00:50:39,190
up in the at 80 degrees north lat

1155
00:50:44,370 --> 00:50:41,170
to dance foul bird but this was probably

1156
00:50:47,520 --> 00:50:44,380
the most desolate region where I've ever

1157
00:50:51,990 --> 00:50:47,530
been and we have a team of people here

1158
00:50:54,210 --> 00:50:52,000
stunning life and ice determining that's

1159
00:50:57,599 --> 00:50:54,220
headed up by Jen I ghen broad who was

1160
00:51:00,230 --> 00:50:57,609
part of the Goddard team on this diagram

1161
00:51:03,809 --> 00:51:00,240
over here we're also studying how

1162
00:51:06,180 --> 00:51:03,819
microorganisms respond to cold

1163
00:51:09,930 --> 00:51:06,190

environments and environmental

1164
00:51:12,180 --> 00:51:09,940
parameters this is a graph that was it's

1165
00:51:14,250 --> 00:51:12,190
actually hand drawn by Vorenus turkey

1166
00:51:16,319 --> 00:51:14,260
who is a graduate student at the

1167
00:51:19,170 --> 00:51:16,329
University of Maryland working with

1168
00:51:21,780 --> 00:51:19,180
Andrew Steele and Frank Rob and what

1169
00:51:24,690 --> 00:51:21,790
she's studying here is a the most

1170
00:51:27,210 --> 00:51:24,700
northern hot spring that's found in a

1171
00:51:30,990 --> 00:51:27,220
terrestrial environment going from a

1172
00:51:33,900 --> 00:51:31,000
very a wet environment up here where the

1173
00:51:36,480 --> 00:51:33,910
spring is actually flowing to where it

1174
00:51:39,630 --> 00:51:36,490
dries out and eventually there's dry

1175
00:51:42,120 --> 00:51:39,640
terraces here which are cooler and drier

1176
00:51:44,700 --> 00:51:42,130
and of course the organisms are

1177
00:51:46,980 --> 00:51:44,710
immobilized in there and she's studying

1178
00:51:50,930 --> 00:51:46,990
the microbial diversity in here and how

1179
00:51:53,069 --> 00:51:50,940
the organisms adapt to cold dry

1180
00:51:56,190 --> 00:51:53,079
environments which is something you

1181
00:52:00,000 --> 00:51:56,200
would find on Mars now we're going to

1182
00:52:02,099 --> 00:52:00,010
switch from this to a Studies on bio

1183
00:52:06,720 --> 00:52:02,109
signatures we've been working on this

1184
00:52:09,750 --> 00:52:06,730
for a while this is a these are figures

1185
00:52:12,780 --> 00:52:09,760
of stratigraphic water columns on the

1186
00:52:16,620 --> 00:52:12,790
this is work by Dominic papineau and

1187
00:52:18,930 --> 00:52:16,630
colleagues and Dominic's has been going

1188
00:52:21,359 --> 00:52:18,940

around the i would say going around the

1189
00:52:24,120 --> 00:52:21,369
world collecting Precambrian rocks or

1190
00:52:27,870 --> 00:52:24,130
various types and something that he is

1191
00:52:30,359 --> 00:52:27,880
especially interested in is the linking

1192
00:52:34,470 --> 00:52:30,369
up the phosphorus cycle with the carbon

1193
00:52:37,940 --> 00:52:34,480
nitrogen and sulfur cycles so what is

1194
00:52:40,680 --> 00:52:37,950
depicted here are two different

1195
00:52:45,480 --> 00:52:40,690
scenarios of potential water columns on

1196
00:52:48,329 --> 00:52:45,490
the left is a scenario where phosphate

1197
00:52:51,120 --> 00:52:48,339
dominated dominated the ocean

1198
00:52:53,109 --> 00:52:51,130
environment and there are anoxic waters

1199
00:52:55,849 --> 00:52:53,119
that occurred

1200
00:52:59,089 --> 00:52:55,859
fairly high up in the water column even

1201
00:53:01,970 --> 00:52:59,099
extending into the euphotic zone where

1202
00:53:05,299 --> 00:53:01,980
there was a light whereas vs. on the

1203
00:53:08,390 --> 00:53:05,309
right-hand side of the diagram over here

1204
00:53:10,759 --> 00:53:08,400
this is an anon phosphate domain where

1205
00:53:14,120 --> 00:53:10,769
productivity is is still a high

1206
00:53:17,599 --> 00:53:14,130
productivity area but the anoxic

1207
00:53:20,480 --> 00:53:17,609
boundary zone is is much lower in the

1208
00:53:23,539 --> 00:53:20,490
water column and looking at the bio

1209
00:53:25,789 --> 00:53:23,549
signatures of nitrogen linking these

1210
00:53:30,319 --> 00:53:25,799
with sulfur and carbon asst is one of

1211
00:53:33,140 --> 00:53:30,329
Dominic's goals in this project we

1212
00:53:35,359 --> 00:53:33,150
dovetail very nicely with James Farquhar

1213
00:53:37,670 --> 00:53:35,369

James has been a collaborator with us

1214
00:53:41,390 --> 00:53:37,680
for the past five years and he's

1215
00:53:45,140 --> 00:53:41,400
continuing he's probably best known for

1216
00:53:48,640 --> 00:53:45,150
his discovery of mass independent

1217
00:53:53,559 --> 00:53:48,650
isotope fractionation of sulfur isotopes

1218
00:53:57,499 --> 00:53:53,569
he has been studying with his students

1219
00:54:00,200 --> 00:53:57,509
particularly Dave Johnson who is now up

1220
00:54:02,499 --> 00:54:00,210
at Harvard so he's created a Harvard

1221
00:54:06,140 --> 00:54:02,509
professor which i think is pretty good

1222
00:54:10,519 --> 00:54:06,150
mass dependent fractionations and what

1223
00:54:14,359 --> 00:54:10,529
he proposes to do in this particular can

1224
00:54:17,809 --> 00:54:14,369
is to study the small mass dependent

1225
00:54:21,950 --> 00:54:17,819
fractionations that have been catalyzed

1226
00:54:23,960 --> 00:54:21,960
with particular cultured microorganisms

1227
00:54:26,900 --> 00:54:23,970
so he's going to do a lot of culture

1228
00:54:30,589 --> 00:54:26,910
work from that I third bio signature

1229
00:54:34,130 --> 00:54:30,599
study is being carried out also by

1230
00:54:37,309 --> 00:54:34,140
Dominic papineau in collaboration with

1231
00:54:40,490 --> 00:54:37,319
Brad DiGregorio and Rhonda Stroud who at

1232
00:54:44,269 --> 00:54:40,500
the Naval Research Lab jinhua Wong who

1233
00:54:46,910 --> 00:54:44,279
was our net one of our nano Sims people

1234
00:54:49,400 --> 00:54:46,920
here myself and and George Cody and

1235
00:54:52,039 --> 00:54:49,410
Andrew Steele and what you see on here

1236
00:54:54,980 --> 00:54:52,049
is a number of tiles that Dominic likes

1237
00:55:00,099 --> 00:54:54,990
to show tiles over here and he's

1238
00:55:04,309 --> 00:55:00,109

studying the these are the Aquila rocks

1239
00:55:05,900 --> 00:55:04,319
QP rocks from Greenland they are about

1240
00:55:08,329 --> 00:55:05,910
3.8 billion

1241
00:55:12,250 --> 00:55:08,339
years old and the origin of the carbon

1242
00:55:16,160 --> 00:55:12,260
which is can be seen in here as as a

1243
00:55:18,559 --> 00:55:16,170
graphite right here and here also in

1244
00:55:20,930 --> 00:55:18,569
here and here these are Rahman scans

1245
00:55:24,529 --> 00:55:20,940
over here looking at the various types

1246
00:55:28,490 --> 00:55:24,539
of carbon and Dominic who is also funded

1247
00:55:33,109 --> 00:55:28,500
by an EXO biology proposal is studying

1248
00:55:35,779 --> 00:55:33,119
these graphite bands inclusions the non

1249
00:55:39,380 --> 00:55:35,789
inclusions their coatings and vaginae

1250
00:55:43,670 --> 00:55:39,390
shins they're found in a variety of

1251
00:55:45,890 --> 00:55:43,680
different places within this rock and

1252
00:55:49,240 --> 00:55:45,900
he's testing the hypothesis as to

1253
00:55:53,440 --> 00:55:49,250
whether or not this carbon may have

1254
00:55:56,450 --> 00:55:53,450
originated through biological processes

1255
00:55:58,609 --> 00:55:56,460
the work is controversial people argue

1256
00:56:01,220 --> 00:55:58,619
about the type of the rock was it

1257
00:56:03,890 --> 00:56:01,230
sedimentary I think people have decided

1258
00:56:06,410 --> 00:56:03,900
on that it's very highly metamorphosed

1259
00:56:08,870 --> 00:56:06,420
and he is having to deal with the fact

1260
00:56:11,329 --> 00:56:08,880
that he's looking at organic carbon

1261
00:56:14,960 --> 00:56:11,339
that's highly metamorphose and in fact

1262
00:56:16,910 --> 00:56:14,970
there are very few examples almost none

1263
00:56:19,819 --> 00:56:16,920

I would say and if we have them it would

1264
00:56:21,769 --> 00:56:19,829
be work of Andrew steals looking at

1265
00:56:25,059 --> 00:56:21,779
similar mechanisms as to what has

1266
00:56:27,859 --> 00:56:25,069
happened to during metamorphism of

1267
00:56:30,680 --> 00:56:27,869
non-biologically formed complex organic

1268
00:56:34,819 --> 00:56:30,690
matter so Dominic has his work cut out

1269
00:56:36,529 --> 00:56:34,829
for him and he proceeds to use the lot

1270
00:56:40,579 --> 00:56:36,539
of the equipment that we have here and

1271
00:56:45,079 --> 00:56:40,589
that the Naval Research Lab going off to

1272
00:56:50,359 --> 00:56:45,089
the side over here who Bob Hazen who has

1273
00:56:53,690 --> 00:56:50,369
just recently published a quite a large

1274
00:56:57,500 --> 00:56:53,700
review paper on mineral evolution it's

1275
00:56:59,809 --> 00:56:57,510
it's highlighted on our website and you

1276
00:57:02,900 --> 00:56:59,819
can see from this diagram over here that

1277
00:57:05,510 --> 00:57:02,910
it's his hypothesis that when life

1278
00:57:09,220 --> 00:57:05,520
evolves on a planet the number of

1279
00:57:12,200 --> 00:57:09,230
mineral species increases dramatically

1280
00:57:15,289 --> 00:57:12,210
we know what's on earth and he has on

1281
00:57:19,849 --> 00:57:15,299
the lower right-hand panel greater than

1282
00:57:23,059 --> 00:57:19,859
4,300 mineral species shortly

1283
00:57:25,130 --> 00:57:23,069
an MSL actually flies it will host

1284
00:57:27,380 --> 00:57:25,140
chemin which is going to be able to do a

1285
00:57:31,299 --> 00:57:27,390
bang-up job of the mineralogy on there

1286
00:57:34,519 --> 00:57:31,309
at the moment we he's estimated about

1287
00:57:37,729 --> 00:57:34,529
5,000 let me excuse me 500 mineral

1288
00:57:40,099 --> 00:57:37,739

species have been found on Mars I'm not

1289
00:57:43,249 --> 00:57:40,109
exactly sure where the Venus number came

1290
00:57:45,349 --> 00:57:43,259
from but this obviously is known for the

1291
00:57:49,400 --> 00:57:45,359
moon from the rocks that we have in hand

1292
00:57:51,229 --> 00:57:49,410
and we we thought about this one and I

1293
00:57:54,890 --> 00:57:51,239
think it's really something that's

1294
00:57:58,370 --> 00:57:54,900
interesting as we send things out in

1295
00:58:00,109 --> 00:57:58,380
space and fly and get data back as to

1296
00:58:03,319 --> 00:58:00,119
whether or not we have a bio signature

1297
00:58:07,120 --> 00:58:03,329
involved on their nearing the end of

1298
00:58:10,009 --> 00:58:07,130
this we're actively involved in testing

1299
00:58:12,529 --> 00:58:10,019
instruments that are a couple of them

1300
00:58:16,269 --> 00:58:12,539
that will be flying on MSL through an a

1301
00:58:19,269 --> 00:58:16,279
step program Andrew Steele is the

1302
00:58:24,470 --> 00:58:19,279
principal investigator on this program

1303
00:58:26,660 --> 00:58:24,480
many of our I go on this field work all

1304
00:58:30,019 --> 00:58:26,670
the time and many of our students and

1305
00:58:33,380 --> 00:58:30,029
postdocs attend these what I have on

1306
00:58:36,769 --> 00:58:33,390
this slide is showing the JPL's cliff

1307
00:58:39,410 --> 00:58:36,779
bot rover over here and we as a

1308
00:58:42,920 --> 00:58:39,420
scientific group have learned to do

1309
00:58:46,220 --> 00:58:42,930
science with a rover we also have Steve

1310
00:58:49,059 --> 00:58:46,230
Squyres it was the p.i on on the Emmy

1311
00:58:52,249 --> 00:58:49,069
our Rovers is also a part of this team

1312
00:58:55,009 --> 00:58:52,259
the ability of astrobiologists to work

1313
00:58:58,460 --> 00:58:55,019

with the likes of steve squyres has been

1314
00:59:01,039 --> 00:58:58,470
very instructive to us and how we can

1315
00:59:02,660 --> 00:59:01,049
design technology on earthen and think

1316
00:59:04,880 --> 00:59:02,670
that it's perfect and we know everything

1317
00:59:07,220 --> 00:59:04,890
about that and then you take this off

1318
00:59:10,309 --> 00:59:07,230
and you try and get a rover to do what

1319
00:59:13,220 --> 00:59:10,319
you could do normally is definitely a

1320
00:59:16,489 --> 00:59:13,230
challenge and now what I have on this

1321
00:59:19,640 --> 00:59:16,499
final slide that's coming up is just

1322
00:59:22,519 --> 00:59:19,650
showing how where we are in in this

1323
00:59:25,660 --> 00:59:22,529
whole procedure and that is actually

1324
00:59:27,890 --> 00:59:25,670
taking a rover and integrating this with

1325
00:59:30,430 --> 00:59:27,900
instruments which turns out to be a very

1326
00:59:33,599 --> 00:59:30,440
hard thing first you have to have the

1327
00:59:34,950 --> 00:59:33,609
intellectual integration of

1328
00:59:37,440 --> 00:59:34,960
not being able to just pick up the

1329
00:59:39,900 --> 00:59:37,450
sample but then and then you have field

1330
00:59:42,450 --> 00:59:39,910
testing of instruments and are they cold

1331
00:59:44,279 --> 00:59:42,460
ready can they work under harsh

1332
00:59:46,589 --> 00:59:44,289
conditions we've made it through that

1333
00:59:48,890 --> 00:59:46,599
step and now we're integrating things

1334
00:59:51,599 --> 00:59:48,900
with the rover and in the next come

1335
00:59:54,509 --> 00:59:51,609
three years going to take out a more

1336
00:59:58,799 --> 00:59:54,519
substantial Rover we're working with the

1337
01:00:01,559 --> 00:59:58,809
pan Conrad at the JPL on native

1338
01:00:04,319 --> 01:00:01,569

fluorescent fluorescence instruments

1339
01:00:06,890 --> 01:00:04,329
with the sam team that's a sample

1340
01:00:10,259 --> 01:00:06,900
analysis of Mars Paul Mahaffy who's p I

1341
01:00:12,950 --> 01:00:10,269
is working with us and Jen I ghen road

1342
01:00:16,170 --> 01:00:12,960
also from Goddard so this is in ER team

1343
01:00:19,650 --> 01:00:16,180
collaborations and finally Dave Blake

1344
01:00:22,170 --> 01:00:19,660
who is who is the p.i of chemin comes

1345
01:00:25,140 --> 01:00:22,180
along with us up to Svalbard on the on

1346
01:00:40,880 --> 01:00:25,150
the Amaze expeditions so that wraps up

1347
01:00:44,819 --> 01:00:40,890
the biology version alright alright so

1348
01:00:46,410 --> 01:00:44,829
this last slide is is always a dangerous

1349
01:00:48,059 --> 01:00:46,420
slide as Dante Lauretta just told me

1350
01:00:50,970 --> 01:00:48,069
about three days ago the NRC that

1351
01:00:52,890 --> 01:00:50,980
graphology is always a subject to less

1352
01:00:54,930 --> 01:00:52,900
interpretation but what I'm trying to

1353
01:00:56,789 --> 01:00:54,940
show in this slide is that in fact we

1354
01:00:58,620 --> 01:00:56,799
have a very interdisciplinary team and

1355
01:01:00,960 --> 01:00:58,630
overall we have a very very

1356
01:01:04,049 --> 01:01:00,970
well-balanced team so if you think of

1357
01:01:05,640 --> 01:01:04,059
text 12 is being astronomy related with

1358
01:01:08,069 --> 01:01:05,650
a lot of crossover from people like

1359
01:01:10,309 --> 01:01:08,079
myself working with people like Alicia

1360
01:01:14,519 --> 01:01:10,319
you'll find that it breaks out to about

1361
01:01:17,400 --> 01:01:14,529
12 12 and 12 and this is actually a very

1362
01:01:20,009 --> 01:01:17,410
very very conservative graph in fact

1363
01:01:22,410 --> 01:01:20,019

I've missed deletion pass to so it's

1364
01:01:24,059 --> 01:01:22,420
just we get called to go a little faster

1365
01:01:25,799 --> 01:01:24,069
but if I were actually to bake cross

1366
01:01:27,180 --> 01:01:25,809
links to where people's interests are

1367
01:01:29,249 --> 01:01:27,190
and where there are discussions lead us

1368
01:01:34,019 --> 01:01:29,259
who would in fact almost be a full field

1369
01:01:35,789 --> 01:01:34,029
so that's that and the last thing you

1370
01:01:40,259 --> 01:01:35,799
may not be able to see because I can't

1371
01:01:41,670 --> 01:01:40,269
see it is the majority of the funding is

1372
01:01:44,579 --> 01:01:41,680
directed towards the sport of past

1373
01:01:45,580 --> 01:01:44,589
postdoctoral scientists at ciw and other

1374
01:01:47,830 --> 01:01:45,590
institutes

1375
01:01:49,780 --> 01:01:47,840
so so much of what you see is the

1376
01:01:51,610 --> 01:01:49,790
science that we do and what our grant is

1377
01:01:54,730 --> 01:01:51,620
is actually the funding is directed

1378
01:01:57,250 --> 01:01:54,740
towards the sport of young people who we

1379
01:02:00,400 --> 01:01:57,260
had dreamt Remender success throughout

1380
01:02:02,220 --> 01:02:00,410
the years and I don't know if you can

1381
01:02:05,470 --> 01:02:02,230
see this anymore so I'll conclude there

1382
01:02:07,780 --> 01:02:05,480
you can see it you can see it okay we

1383
01:02:10,390 --> 01:02:07,790
can't see all right well it was up here

1384
01:02:11,650 --> 01:02:10,400
so that's the essence of it I guess I

1385
01:02:13,210 --> 01:02:11,660
would just say that you know match rank

1386
01:02:15,970 --> 01:02:13,220
is a classic example Julie Hoover's

1387
01:02:18,340 --> 01:02:15,980
another Matt Matt we funded and can run

1388
01:02:21,580 --> 01:02:18,350

as a student John Barrow says he was an

1389
01:02:25,750 --> 01:02:21,590
nei NRC postdoc in cam 3 and now he's a

1390
01:02:27,730 --> 01:02:25,760
co I in cam 5 and the number of

1391
01:02:29,140 --> 01:02:27,740
postdoctoral associates that we've been

1392
01:02:31,750 --> 01:02:29,150
able to support through this has been

1393
01:02:33,610 --> 01:02:31,760
spectacular and they're now across the

1394
01:02:35,350 --> 01:02:33,620
country in many many major institutions

1395
01:02:37,540 --> 01:02:35,360
Dave Johnson was supported through our

1396
01:02:39,640 --> 01:02:37,550
any I can three it's now a young faculty

1397
01:02:42,340 --> 01:02:39,650
member at Harvard so what you're seeing

1398
01:02:44,320 --> 01:02:42,350
in terms of what the proposal looks like

1399
01:02:47,650 --> 01:02:44,330
Anna budgetary sense is actually a very

1400
01:02:49,360 --> 01:02:47,660
strong educational component and we

1401
01:02:52,180 --> 01:02:49,370
serve as mentorship in a broad array of

1402
01:02:53,530 --> 01:02:52,190
astrobiological problems so I'll stop

1403
01:02:58,930 --> 01:02:53,540
there do you have any questions you have

1404
01:03:00,610 --> 01:02:58,940
to okay George and and all the rest of

1405
01:03:03,010 --> 01:03:00,620
the speakers thank you very much i think

1406
01:03:04,630 --> 01:03:03,020
this worked out extraordinarily well you

1407
01:03:07,630 --> 01:03:04,640
guys did a fabulous job putting this

1408
01:03:11,050 --> 01:03:07,640
together we do have some time for

1409
01:03:15,430 --> 01:03:11,060
questions but i would encourage you all

1410
01:03:17,680 --> 01:03:15,440
to communicate with the investigators on

1411
01:03:20,260 --> 01:03:17,690
the carnegie team by email etc as you

1412
01:03:22,510 --> 01:03:20,270
know the purpose of these seminars is to

1413
01:03:26,050 --> 01:03:22,520

enable collaboration and integration

1414
01:03:28,690 --> 01:03:26,060
across the Institute and so feel free to

1415
01:03:30,190 --> 01:03:28,700
email the Carnegie investigators and

1416
01:03:32,620 --> 01:03:30,200
their colleagues and everybody who's

1417
01:03:35,740 --> 01:03:32,630
either been speaking today or whose work

1418
01:03:37,780 --> 01:03:35,750
has been described and we encourage all

1419
01:03:39,190 --> 01:03:37,790
the interactions possible and right now

1420
01:03:43,060 --> 01:03:39,200
we'll throw it open for some

1421
01:03:44,950 --> 01:03:43,070
interactions in QA you can either raise

1422
01:03:55,410 --> 01:03:44,960
your hand in WebEx and Marco will call

1423
01:04:03,270 --> 01:04:01,829
we have any hands raised if anybody has

1424
01:04:05,520 --> 01:04:03,280
a question why don't you just open up

1425
01:04:12,059 --> 01:04:05,530
your mic and ask and then we'll call on

1426
01:04:15,900 --> 01:04:12,069
the others by WebEx and if you don't

1427
01:04:17,599 --> 01:04:15,910
have a question that's okay too oh it's

1428
01:04:21,240 --> 01:04:17,609
not we'd like to demonstrate

1429
01:04:23,490 --> 01:04:21,250
interactivity and be George okay Carl

1430
01:04:32,910 --> 01:04:23,500
all right we'll sit here until somebody

1431
01:04:36,450 --> 01:04:32,920
asks a question somebody asked don't be

1432
01:04:40,020 --> 01:04:36,460
shy okay Lauren has a question Georgia

1433
01:04:42,720 --> 01:04:40,030
Tech I'm trying to figure out how to get

1434
01:04:46,289 --> 01:04:42,730
my cat am I on you can you hear me I can

1435
01:04:48,210 --> 01:04:46,299
hear you you can hear me okay I want to

1436
01:04:53,940 --> 01:04:48,220
ask George about his little nodules as

1437
01:04:56,309 --> 01:04:53,950
organic nodules south and asked if he

1438
01:04:58,950 --> 01:04:56,319

have figured out the molecular weight of

1439
01:05:02,099 --> 01:04:58,960
these polymers and if he's tried to do

1440
01:05:04,440 --> 01:05:02,109
math spectrometry of their you know of

1441
01:05:06,359 --> 01:05:04,450
their fragment them and that sort of

1442
01:05:10,650 --> 01:05:06,369
thing I was a very facility parliament

1443
01:05:12,930 --> 01:05:10,660
yo we are to it like we've only just

1444
01:05:15,900 --> 01:05:12,940
literally these things are fresh off the

1445
01:05:17,910 --> 01:05:15,910
press we we just discovered that a lot

1446
01:05:21,059 --> 01:05:17,920
of what 4-valve hi I mean this is it

1447
01:05:22,859 --> 01:05:21,069
others have known and and this is why we

1448
01:05:25,620 --> 01:05:22,869
were terribly surprised to explore this

1449
01:05:28,339 --> 01:05:25,630
formaldehyde question but but precisely

1450
01:05:31,020 --> 01:05:28,349
what controls the the nano scale

1451
01:05:33,480 --> 01:05:31,030
formation of these little spheres is not

1452
01:05:35,789 --> 01:05:33,490
known and I've had an opportunity to the

1453
01:05:38,250 --> 01:05:35,799
canopy you want to tell about the

1454
01:05:41,400 --> 01:05:38,260
chemistry the chemistry i think i assume

1455
01:05:43,770 --> 01:05:41,410
quite well if i were to give it in a

1456
01:05:45,030 --> 01:05:43,780
series of steps what would your looking

1457
01:05:47,089 --> 01:05:45,040
at is there are four most type

1458
01:05:49,740 --> 01:05:47,099
condensations progress of elimination

1459
01:05:53,309 --> 01:05:49,750
reactions all in sort of a very random

1460
01:05:55,620 --> 01:05:53,319
sort of system to Tom oars ations a

1461
01:05:57,240 --> 01:05:55,630
midori rearrangements but the key seems

1462
01:05:59,010 --> 01:05:57,250
to be diels-alder cycloaddition

1463
01:06:00,510 --> 01:05:59,020

reactions it starts allowed to build up

1464
01:06:01,859 --> 01:06:00,520
a three-dimensional react at three

1465
01:06:04,440 --> 01:06:01,869
dimensional network so they they're

1466
01:06:06,390 --> 01:06:04,450
completely insoluble so they're not very

1467
01:06:08,550 --> 01:06:06,400
amenable to mass spectrometry so now it

1468
01:06:10,290 --> 01:06:08,560
is ironically to study them further

1469
01:06:13,590 --> 01:06:10,300
we have to find neck ways of now taking

1470
01:06:24,750 --> 01:06:13,600
them apart in a systematic way so that's

1471
01:06:26,790 --> 01:06:24,760
what we're doing there are no more hands

1472
01:06:31,830 --> 01:06:26,800
raised in webex bible you have a

1473
01:06:33,900 --> 01:06:31,840
question yep that's why you're like I

1474
01:06:36,600 --> 01:06:33,910
just had a question the follow-up on

1475
01:06:38,520 --> 01:06:36,610
George's comment I've been sitting here

1476
01:06:41,310 --> 01:06:38,530
thinking about these hollow spheres

1477
01:06:44,600 --> 01:06:41,320
myself and wondering how the heck to get

1478
01:06:48,080 --> 01:06:44,610
a hollow structure and something as

1479
01:06:51,810 --> 01:06:48,090
processed as meteoritic material and

1480
01:06:57,390 --> 01:06:51,820
particular if it was preceded by some

1481
01:07:00,150 --> 01:06:57,400
icy body or was a icy matrix what kind

1482
01:07:03,480 --> 01:07:00,160
of a sequence with lead from that I see

1483
01:07:09,120 --> 01:07:03,490
matrix towards a matrix that had hollow

1484
01:07:11,100 --> 01:07:09,130
spherical inclusions I could give you my

1485
01:07:14,420 --> 01:07:11,110
opinion but maybe Larry what's a giant

1486
01:07:17,010 --> 01:07:14,430
let's hear Joyce's well it we don't know

1487
01:07:19,230 --> 01:07:17,020
obviously that that fit image the

1488
01:07:22,290 --> 01:07:19,240

beautiful folks I'm beam section that

1489
01:07:24,480 --> 01:07:22,300
Rhonda Stroud made and that we've

1490
01:07:27,120 --> 01:07:24,490
analyzed six different ways to Sunday as

1491
01:07:29,640 --> 01:07:27,130
they say caught us all by surprise she

1492
01:07:31,140 --> 01:07:29,650
just did a random section through an

1493
01:07:32,880 --> 01:07:31,150
ordinary chondrite and there in the

1494
01:07:34,440 --> 01:07:32,890
center was this little organic doughnut

1495
01:07:36,540 --> 01:07:34,450
as you observe it of course it's a

1496
01:07:38,040 --> 01:07:36,550
hollow sphere so it begs the question

1497
01:07:39,810 --> 01:07:38,050
wet weather was always hollow whether

1498
01:07:42,270 --> 01:07:39,820
there was a fluid that once was in the

1499
01:07:45,630 --> 01:07:42,280
core of this material but the shape of

1500
01:07:47,280 --> 01:07:45,640
the thing and the fact that no cake oh

1501
01:07:49,440 --> 01:07:47,290
and nakamura Messenger has been studies

1502
01:07:51,090 --> 01:07:49,450
quite a bit and the high-resolution you

1503
01:07:54,210 --> 01:07:51,100
almost start seeking chrétien airy

1504
01:07:56,030 --> 01:07:54,220
features so so my tendency is to look at

1505
01:07:58,950 --> 01:07:56,040
these and think they scream out as

1506
01:08:00,360 --> 01:07:58,960
products of aqueous processing but then

1507
01:08:01,800 --> 01:08:00,370
Larry knit ler who doesn't want to talk

1508
01:08:03,930 --> 01:08:01,810
about this right now could tell you

1509
01:08:05,820 --> 01:08:03,940
something about the isotopes which say

1510
01:08:10,050 --> 01:08:05,830
that may perhaps a very different story

1511
01:08:11,910 --> 01:08:10,060
well I I guess what huh yeah Larry's my

1512
01:08:14,610 --> 01:08:11,920
tecno I'm somewhere in there I guess uh

1513
01:08:17,370 --> 01:08:14,620

Harrigan oh um what we're finding with

1514
01:08:19,289 --> 01:08:17,380
these is one they're very diverse set of

1515
01:08:21,459 --> 01:08:19,299
things that they're not all hollow some

1516
01:08:24,269 --> 01:08:21,469
of them are solid

1517
01:08:26,859 --> 01:08:24,279
work by lawrence Garvey at Arizona State

1518
01:08:28,689 --> 01:08:26,869
doing fibbing of these things is showing

1519
01:08:30,249 --> 01:08:28,699
that some have multiple little holes

1520
01:08:32,649 --> 01:08:30,259
within them they're not just necessarily

1521
01:08:34,870 --> 01:08:32,659
single hollow things but many of them

1522
01:08:38,349 --> 01:08:34,880
are where we're starting to get good

1523
01:08:41,379 --> 01:08:38,359
chemical data carbon x-ray edge

1524
01:08:42,729 --> 01:08:41,389
spectroscopy on many of these globules

1525
01:08:46,660 --> 01:08:42,739
to compare with the surrounding material

1526
01:08:48,099 --> 01:08:46,670
in the IOM and in any given meteorite

1527
01:08:51,219 --> 01:08:48,109
they seem to bear a lot of chemical

1528
01:08:53,349 --> 01:08:51,229
similarities to the general IOM of that

1529
01:08:54,729 --> 01:08:53,359
meteorite they're not all one population

1530
01:08:56,289 --> 01:08:54,739
that's mixed in with the different

1531
01:08:57,849 --> 01:08:56,299
meteorites that they're processing seems

1532
01:09:00,189 --> 01:08:57,859
to be related to the overall processing

1533
01:09:02,439 --> 01:09:00,199
of the meteorites and they're typically

1534
01:09:03,999 --> 01:09:02,449
isotopically quite anomalous relative to

1535
01:09:05,739 --> 01:09:04,009
the other organic matter even though

1536
01:09:07,539 --> 01:09:05,749
they're chemically similar they are

1537
01:09:10,989 --> 01:09:07,549
typically more enriched in deuterium in

1538
01:09:13,450 --> 01:09:10,999

nitrogen 15 and all of this has to go

1539
01:09:16,660 --> 01:09:13,460
into finding an explanation for them we

1540
01:09:18,849 --> 01:09:16,670
don't have such an explanation yet but I

1541
01:09:21,279 --> 01:09:18,859
assume they they constitute a tiny

1542
01:09:25,870 --> 01:09:21,289
fraction with total organic material

1543
01:09:27,370 --> 01:09:25,880
where I am they actually I don't know

1544
01:09:28,930 --> 01:09:27,380
about dominant in that this is an

1545
01:09:31,329 --> 01:09:28,940
extremely important question but they're

1546
01:09:33,430 --> 01:09:31,339
it's a non-trivial amount especially in

1547
01:09:36,640 --> 01:09:33,440
a couple of the meteorites like Tagish

1548
01:09:39,399 --> 01:09:36,650
Lake and bells which is an unusual cm

1549
01:09:41,200 --> 01:09:39,409
chondrite both of them it's a major

1550
01:09:43,839 --> 01:09:41,210
fraction of the IOM is made of this

1551
01:09:45,669 --> 01:09:43,849
these little globules i would say that

1552
01:09:47,919 --> 01:09:45,679
Rhonda sectioned randomly through an

1553
01:09:50,289 --> 01:09:47,929
ordinary chondrite and picked up one

1554
01:09:52,089 --> 01:09:50,299
just like that so that's the same one

1555
01:09:53,349 --> 01:09:52,099
sample that still the statistics must

1556
01:09:55,589 --> 01:09:53,359
tell you there's paramount in there

1557
01:09:57,969 --> 01:09:55,599
though is it is it correct dundas to

1558
01:10:01,330 --> 01:09:57,979
categorize this as saying that the most

1559
01:10:06,239 --> 01:10:01,340
primitive cometary material it has the

1560
01:10:09,399 --> 01:10:06,249
highest fraction of these menos girls

1561
01:10:12,160 --> 01:10:09,409
that we don't know we have found two of

1562
01:10:15,129 --> 01:10:12,170
these nano sterols in the star death in

1563
01:10:18,669 --> 01:10:15,139

the commentary build two samples how was

1564
01:10:21,640 --> 01:10:18,679
edited huh oh but don't you regard

1565
01:10:26,290 --> 01:10:21,650
targus lake is cometary material or

1566
01:10:27,759 --> 01:10:26,300
closed out of it well I don't know of

1567
01:10:31,839 --> 01:10:27,769
any evidence that would Lake Tagish Lake

1568
01:10:32,890 --> 01:10:31,849
to a comment but certainly is far more

1569
01:10:36,939 --> 01:10:32,900
primitive than most

1570
01:10:39,550 --> 01:10:36,949
other see I see no it's actually more

1571
01:10:40,990 --> 01:10:39,560
process than some of the other some of

1572
01:10:43,180 --> 01:10:41,000
the other carbonaceous chondrites it's

1573
01:10:44,830 --> 01:10:43,190
very primitive in some respects but it's

1574
01:10:47,530 --> 01:10:44,840
organics are actually somewhat processed

1575
01:10:49,020 --> 01:10:47,540
relative to those in other meteorites we

1576
01:10:55,570 --> 01:10:49,030
should have you come a bit of a seminar

1577
01:10:58,570 --> 01:10:55,580
be happy to good the Chris did you have

1578
01:11:01,750 --> 01:10:58,580
a question yeah we had two questions

1579
01:11:05,080 --> 01:11:01,760
first staying on the organic matter

1580
01:11:09,250 --> 01:11:05,090
question from Larry we were curious

1581
01:11:11,140 --> 01:11:09,260
about how often the deuterium and 15 hot

1582
01:11:12,640 --> 01:11:11,150
spots are correlated versus

1583
01:11:14,979 --> 01:11:12,650
non-correlated looked like sometimes

1584
01:11:21,220 --> 01:11:14,989
they then 15 in the Tyrian is the same

1585
01:11:23,560 --> 01:11:21,230
spot sometimes it's not um yes no it's a

1586
01:11:26,080 --> 01:11:23,570
good question I don't have a way to

1587
01:11:28,510 --> 01:11:26,090
quantitatively answer that in simple

1588
01:11:29,979 --> 01:11:28,520

sentences I what I would say is a lot we

1589
01:11:32,080 --> 01:11:29,989
see correlations and we see anti

1590
01:11:35,140 --> 01:11:32,090
correlations in in this material that

1591
01:11:36,610 --> 01:11:35,150
some sub materials have both some have

1592
01:11:41,350 --> 01:11:36,620
one some have the other and there's no

1593
01:11:44,410 --> 01:11:41,360
simple simple correlation I her second

1594
01:11:46,540 --> 01:11:44,420
I'll start going go go ahead okay our

1595
01:11:48,130 --> 01:11:46,550
second question actually is about meth

1596
01:11:50,649 --> 01:11:48,140
addicts are son so I'm not Ali's

1597
01:11:53,229 --> 01:11:50,659
analysis so Barris isn't around it may

1598
01:11:55,169 --> 01:11:53,239
not be answerable but um we were curious

1599
01:11:58,750 --> 01:11:55,179
that the slide set ninety percent

1600
01:12:01,149 --> 01:11:58,760
similar to Montana star sign Ace species

1601
01:12:02,830 --> 01:12:01,159
and we're wondering how how much that

1602
01:12:04,450 --> 01:12:02,840
would drop off if you went to the

1603
01:12:07,120 --> 01:12:04,460
ninety-five percent level or something

1604
01:12:10,750 --> 01:12:07,130
because that's a pretty much I think it

1605
01:12:12,880 --> 01:12:10,760
was eighty percent wasn't it that's uh I

1606
01:12:16,689 --> 01:12:12,890
thought it was a date it was 800 were

1607
01:12:18,610 --> 01:12:16,699
within ninety percent of 800 clones were

1608
01:12:19,810 --> 01:12:18,620
with the ninety percent 800 sequences

1609
01:12:29,710 --> 01:12:19,820
were with ninety percent or something

1610
01:12:33,310 --> 01:12:29,720
like that sorry here we go 800 species

1611
01:12:34,810 --> 01:12:33,320
oh okay those are the otiose I wouldn't

1612
01:12:37,390 --> 01:12:34,820
know the answer to that you'd have to

1613
01:12:39,940 --> 01:12:37,400

but you can email john burroughs that

1614
01:12:46,200 --> 01:12:39,950
would be a great idea or Julie Hubert

1615
01:12:51,160 --> 01:12:49,330
hi this is Sean McLennon at Montana

1616
01:12:53,380 --> 01:12:51,170
State I've got a question concerning a

1617
01:12:55,780 --> 01:12:53,390
Robert Hazen's work and the idea of the

1618
01:12:57,460 --> 01:12:55,790
mineral evolution and I was just one I'm

1619
01:12:58,990 --> 01:12:57,470
curious about you know the claw

1620
01:13:02,800 --> 01:12:59,000
different planets and DIF different

1621
01:13:04,990 --> 01:13:02,810
atmospheric composition on those is what

1622
01:13:07,300 --> 01:13:05,000
we see I think there were forty three

1623
01:13:08,680 --> 01:13:07,310
hundred different mineral species on the

1624
01:13:11,560 --> 01:13:08,690
earth to that is that really just a side

1625
01:13:13,540 --> 01:13:11,570
effect of oxygenation or is there

1626
01:13:16,510 --> 01:13:13,550
something else going on no it's very

1627
01:13:18,520 --> 01:13:16,520
much I I can't I can't Bob's not here so

1628
01:13:21,400 --> 01:13:18,530
I'll try to answer for you is it yes see

1629
01:13:23,590 --> 01:13:21,410
if if you go into his paper he would

1630
01:13:26,350 --> 01:13:23,600
argue that that coming through the great

1631
01:13:28,360 --> 01:13:26,360
oxygenation event led to of course a

1632
01:13:29,830 --> 01:13:28,370
very broad distribution of highly

1633
01:13:32,230 --> 01:13:29,840
oxygenated species of wouldn't exist

1634
01:13:34,180 --> 01:13:32,240
prior to that so it also changes the

1635
01:13:36,160 --> 01:13:34,190
weathering characteristics of the

1636
01:13:37,900 --> 01:13:36,170
countenance of I got the right so one

1637
01:13:39,610 --> 01:13:37,910
could reasonably assume that the changes

1638
01:13:40,990 --> 01:13:39,620

of made if you know of course of that

1639
01:13:44,380 --> 01:13:41,000
Miss fear chemistry would have profound

1640
01:13:46,030 --> 01:13:44,390
effects on on such a weathering cycle

1641
01:13:47,590 --> 01:13:46,040
and the recycling site and recycling

1642
01:13:49,180 --> 01:13:47,600
chemistry associated with it it could

1643
01:13:51,040 --> 01:13:49,190
you know turn it will eventually start

1644
01:13:54,550 --> 01:13:51,050
to change the chemistry the mental right

1645
01:14:04,300 --> 01:13:54,560
so is that answer but I know yeah and

1646
01:14:06,460 --> 01:14:04,310
compass a proud yeah check it out okay

1647
01:14:08,590 --> 01:14:06,470
well I would like to thank everyone who

1648
01:14:11,050 --> 01:14:08,600
participated in this once again i think

1649
01:14:14,770 --> 01:14:11,060
this Q&A just illustrates the NAI

1650
01:14:18,220 --> 01:14:14,780
process at work so thank you all again

1651
01:14:20,140 --> 01:14:18,230
we will be hearing on Wednesday same

1652
01:14:22,090 --> 01:14:20,150
time same channel from Dave Desmarais

1653
01:14:25,120 --> 01:14:22,100
who's sitting right here with us at nai

1654
01:14:26,830 --> 01:14:25,130
central and then we'll be continuing on

1655
01:14:29,620 --> 01:14:26,840
so thank you all again this has been

1656
01:14:32,100 --> 01:14:29,630
very very effective and thank you

1657
01:14:34,859 --> 01:14:32,110
particularly George and

1658
01:14:37,379 --> 01:14:34,869
Marilyn Alicia Steve for all your

1659
01:14:39,149 --> 01:14:37,389
preparation and George also for zooming

1660
01:14:42,209 --> 01:14:39,159
in the camera on the speaker's I think

1661
01:14:44,760 --> 01:14:42,219
that was just an exemplary way of really

1662
01:14:46,649 --> 01:14:44,770
making the personal connection it's so

1663
01:14:49,320 --> 01:14:46,659

you need a fabulous job so thanks