AbSciCon 2019

1
00:00:00,790 --> 00:00:07,320
[Music]

2
00:00:11,589 --> 00:00:09,150
[Applause]

3
00:00:16,150 --> 00:00:11,599
thank you all for sticking around so

4
00:00:18,279 --> 00:00:16,160
close to lunch so an important part of

5
00:00:20,650 --> 00:00:18,289
this title is low logistical costs I put

6
00:00:23,769 --> 00:00:20,660
up this picture of our set up in

7
00:00:26,470 --> 00:00:23,779
Greenland in 2014 and in which we

8
00:00:30,339 --> 00:00:26,480
piloted a probe a melt probe to 400

9
00:00:32,650 --> 00:00:30,349
meters depth that in mind as I show you

10
00:00:34,510 --> 00:00:32,660
some other drilling out operations in a

11
00:00:38,170 --> 00:00:34,520
couple of minutes

12
00:00:40,779 --> 00:00:38,180
so Tim Elam and Justin Burnett and I are

13
00:00:43,090 --> 00:00:40,789

responsible for this narrow part of the

14
00:00:46,209 --> 00:00:43,100
work that I'm going to discuss today but

15
00:00:48,549 --> 00:00:46,219
this this part of the work sits within

16
00:00:52,079 --> 00:00:48,559
the context of a broader portfolio of

17
00:00:55,119 --> 00:00:52,089
projects funded by NASA and by NSF and

18
00:00:58,599 --> 00:00:55,129
involving a number of Co eyes that I

19
00:01:02,349 --> 00:00:58,609
want to acknowledge Jill mikake and her

20
00:01:05,920 --> 00:01:02,359
student Caleb Schuler are helping us to

21
00:01:10,149 --> 00:01:05,930
develop microbial clean sampling in this

22
00:01:12,760 --> 00:01:10,159
sort of probe Scott Tyler and John selca

23
00:01:14,680 --> 00:01:12,770
are helping us to develop Rahma and

24
00:01:15,940 --> 00:01:14,690
distributed temperature sensing so that

25
00:01:17,380 --> 00:01:15,950
we can measure temperature profiles

26
00:01:20,560 --> 00:01:17,390
everywhere between the surface of the

27
00:01:22,000 --> 00:01:20,570
ice and the probe as it descends Ben

28
00:01:23,140 --> 00:01:22,010
Hill and Paul Kantner a couple of

29
00:01:25,990 --> 00:01:23,150
students that I've worked with in

30
00:01:28,840 --> 00:01:26,000
developing numerical modeling that for

31
00:01:31,030 --> 00:01:28,850
the closure of the melt hole and what

32
00:01:33,280 --> 00:01:31,040
happens when you have antifreeze in it

33
00:01:34,810 --> 00:01:33,290
as you'll see in a minute and Paul

34
00:01:40,660 --> 00:01:34,820
kinder Nick Logan also have helped with

35
00:01:43,030 --> 00:01:40,670
experiments so to start out I want to

36
00:01:47,980 --> 00:01:43,040
emphasize the science driver for this

37
00:01:50,890 --> 00:01:47,990
work there are beneath the Antarctic Ice

38
00:01:55,260 --> 00:01:50,900

Sheet there are at least 400 sub glacial

39
00:01:58,090 --> 00:01:55,270
lakes they are variously connected by

40
00:02:02,290 --> 00:01:58,100
streams and rivers and maybe marshes

41
00:02:05,560 --> 00:02:02,300
they are a very diverse group of of

42
00:02:07,360 --> 00:02:05,570
water bodies ranging in size up to sort

43
00:02:12,759 --> 00:02:07,370
of Lake Ontario size in the case of Lake

44
00:02:15,790 --> 00:02:12,769
Vostok and the point is that these

45
00:02:18,880 --> 00:02:15,800
things are chemically and gyah

46
00:02:20,620 --> 00:02:18,890
physically quite various some of them

47
00:02:21,970 --> 00:02:20,630
have melting going on at their lids so

48
00:02:22,180 --> 00:02:21,980
they have oxygen inputs some of them

49
00:02:24,310 --> 00:02:22,190
have

50
00:02:27,700 --> 00:02:24,320
other sorts of varying geochemical

51
00:02:31,090 --> 00:02:27,710
inputs so they are 400 natural

52
00:02:38,310 --> 00:02:31,100
laboratories for understanding how life

53
00:02:40,960 --> 00:02:38,320
may work under ice in various ways and I

54
00:02:43,330 --> 00:02:40,970
think that that is critical to

55
00:02:44,590 --> 00:02:43,340
understand how life may work as we start

56
00:02:47,760 --> 00:02:44,600
to think about the outer solar system

57
00:02:50,290 --> 00:02:47,770
and modeling Europa and Enceladus and

58
00:02:52,810 --> 00:02:50,300
modeling or how we would go about

59
00:02:59,290 --> 00:02:52,820
analysis of blue material from those

60
00:03:01,060 --> 00:02:59,300
places so 400 lakes 400 very different

61
00:03:03,070 --> 00:03:01,070
places you need to sample some fair

62
00:03:05,740 --> 00:03:03,080
fraction of them to learn what they have

63
00:03:07,810 --> 00:03:05,750

to tell you and the problem is that

64
00:03:12,160 --> 00:03:07,820
current methods for sampling those lakes

65
00:03:14,800 --> 00:03:12,170
are expensive a good example of this is

66
00:03:17,670 --> 00:03:14,810
the recent wizard project which more

67
00:03:20,050 --> 00:03:17,680
recently has become the salsa project

68
00:03:22,570 --> 00:03:20,060
sampling to lakes in West Antarctica

69
00:03:25,540 --> 00:03:22,580
beneath 800 meters of ice

70
00:03:29,530 --> 00:03:25,550
these were scientifically extremely

71
00:03:31,420 --> 00:03:29,540
productive projects but they are

72
00:03:32,770 --> 00:03:31,430
expensive on the order of 10 million

73
00:03:35,729 --> 00:03:32,780
dollars so that means that you're not

74
00:03:39,760 --> 00:03:35,739
going to go to very many places this way

75
00:03:42,190 --> 00:03:39,770
especially not very fast if we're

76
00:03:45,520 --> 00:03:42,200
interested to try to get information and

77
00:03:53,530 --> 00:03:45,530
insight prior to missions to the outer

78
00:03:57,220 --> 00:03:53,540
solar system so so we've been developing

79
00:04:01,199 --> 00:03:57,230
a alternative way to get into some

80
00:04:04,720 --> 00:04:01,209
larger fraction of those 400 lakes and

81
00:04:07,630 --> 00:04:04,730
in particular this is a thermal melt

82
00:04:09,670 --> 00:04:07,640
probe so it's it's it melts its way down

83
00:04:14,350 --> 00:04:09,680
into the ice using electrical power

84
00:04:16,120 --> 00:04:14,360
supplied from the ice surface and this

85
00:04:18,250 --> 00:04:16,130
is our set up again

86
00:04:20,680 --> 00:04:18,260
in Greenland so there's just a tent with

87
00:04:24,670 --> 00:04:20,690
some high voltage power supplies and

88
00:04:27,280 --> 00:04:24,680

Honda generators fuel depot and the ice

89
00:04:30,850 --> 00:04:27,290
diver this is the whole kit to get to

90
00:04:33,400 --> 00:04:30,860
400 meters it was about half a Bell

91
00:04:36,070 --> 00:04:33,410
Helicopter load typical air Greenland

92
00:04:40,260 --> 00:04:36,080
Bell Helicopter

93
00:04:43,930 --> 00:04:40,270
and so this is logistically much lighter

94
00:04:45,570 --> 00:04:43,940
that means we can go more places and one

95
00:04:49,360 --> 00:04:45,580
other thing to think about here is that

96
00:04:53,470 --> 00:04:49,370
thus far as many it may change but thus

97
00:04:54,850 --> 00:04:53,480
far this kind of melt probe is the the

98
00:04:57,970 --> 00:04:54,860
only technology that has been

99
00:05:01,180 --> 00:04:57,980
demonstrated to penetrate to hundreds of

100
00:05:03,880 --> 00:05:01,190
meters in the ice with near autonomy so

101
00:05:06,400 --> 00:05:03,890
that has continued to make it a

102
00:05:14,320 --> 00:05:06,410
candidate component technology for

103
00:05:17,020 --> 00:05:14,330
Europa system however a classical

104
00:05:20,110 --> 00:05:17,030
thermal melt probe lets the ice above

105
00:05:21,940 --> 00:05:20,120
the probe as you descend freeze so you

106
00:05:25,690 --> 00:05:21,950
don't get it back it's not recoverable

107
00:05:27,340 --> 00:05:25,700
and that means that we can't use it to

108
00:05:28,750 --> 00:05:27,350
go into analytics of glacial lakes

109
00:05:31,000 --> 00:05:28,760
because certainly no one's going to let

110
00:05:35,610 --> 00:05:31,010
us leave a probe in the lake and pollute

111
00:05:39,490 --> 00:05:35,620
it and also you can't get samples back

112
00:05:41,650 --> 00:05:39,500
so we have started to develop an

113
00:05:45,300 --> 00:05:41,660

extension to this technology based on

114
00:05:47,890 --> 00:05:45,310
this idea so the key idea here is that

115
00:05:51,220 --> 00:05:47,900
the melt hole doesn't refreeze instantly

116
00:05:54,730 --> 00:05:51,230
as you go down takes hours even at East

117
00:05:57,070 --> 00:05:54,740
Antarctic temperatures and so you can

118
00:05:59,050 --> 00:05:57,080
inject an antifreeze in particular

119
00:06:00,730 --> 00:05:59,060
ethanol is a good antifreeze I'll

120
00:06:04,750 --> 00:06:00,740
explain why in a minute

121
00:06:06,700 --> 00:06:04,760
to arrest the the whole refreezing and

122
00:06:08,860 --> 00:06:06,710
then you can deploy cable from the

123
00:06:10,330 --> 00:06:08,870
surface you don't have to carry it all

124
00:06:12,070 --> 00:06:10,340
in the vehicle so you can keep a small

125
00:06:14,710 --> 00:06:12,080
vehicle and go deep with all of those

126
00:06:17,980 --> 00:06:14,720
just logistical advantages inherent in

127
00:06:19,600 --> 00:06:17,990
that you can recover samples and you

128
00:06:21,760 --> 00:06:19,610
also get to deploy fibers that would be

129
00:06:23,380 --> 00:06:21,770
hard to fit in your vehicle like fiber

130
00:06:26,290 --> 00:06:23,390
optic cable to do this temperature

131
00:06:28,330 --> 00:06:26,300
measurement so the the schematic idea

132
00:06:31,030 --> 00:06:28,340
here is that the probe goes down and we

133
00:06:34,900 --> 00:06:31,040
inject this ethanol at some distance

134
00:06:37,330 --> 00:06:34,910
above it we choose ethanol because it's

135
00:06:39,130 --> 00:06:37,340
lighter than water and ice sheets are

136
00:06:40,660 --> 00:06:39,140
colder at the top than they are at the

137
00:06:43,150 --> 00:06:40,670
bottom so you need more antifreeze at

138
00:06:45,310 --> 00:06:43,160

the top and you want that to float on

139
00:06:48,839 --> 00:06:45,320
the more dilute solution beneath so

140
00:06:54,299 --> 00:06:48,849
ethanol is a more miraculous material

141
00:06:56,399 --> 00:06:54,309
then perhaps you realized however some

142
00:06:59,070 --> 00:06:56,409
of you might be hot water drillers or

143
00:07:01,290 --> 00:06:59,080
you might know hot water drillers who

144
00:07:04,559 --> 00:07:01,300
will tell you that wait a minute if you

145
00:07:06,689 --> 00:07:04,569
pour ethanol down a melt hole you'll get

146
00:07:08,939 --> 00:07:06,699
a hole full of slush and everything will

147
00:07:11,760 --> 00:07:08,949
just be clogged up so you might be

148
00:07:14,369 --> 00:07:11,770
skeptical of this solution about just

149
00:07:17,850 --> 00:07:14,379
outlined for you let me explain based on

150
00:07:20,699 --> 00:07:17,860
numerical modeling and now lab work that

151
00:07:22,409 --> 00:07:20,709
we've done why we we think that is that

152
00:07:25,790 --> 00:07:22,419
the hot water drillers do get holes full

153
00:07:29,040 --> 00:07:25,800
of slush and why we can avoid that so

154
00:07:31,499 --> 00:07:29,050
here is the situation just after you've

155
00:07:35,699 --> 00:07:31,509
drilled a hole you have a column full of

156
00:07:37,529 --> 00:07:35,709
water at zero C and there's some warm

157
00:07:39,989 --> 00:07:37,539
ice outside the hole and out here at the

158
00:07:41,159 --> 00:07:39,999
far field there's some distant

159
00:07:43,290 --> 00:07:41,169
temperature that's the ice sheet

160
00:07:44,879 --> 00:07:43,300
temperature at that depth what you

161
00:07:46,409 --> 00:07:44,889
really would like ideally is to wave a

162
00:07:48,799 --> 00:07:46,419
wand and just have everything be

163
00:07:51,989 --> 00:07:48,809

isothermal with antifreeze in this hole

164
00:07:53,639 --> 00:07:51,999
of course you can't quite do that so but

165
00:07:56,040 --> 00:07:53,649
the point is that hot water drilling

166
00:07:59,189 --> 00:07:56,050
warms up ice outside the hole quite a

167
00:08:00,929 --> 00:07:59,199
bit because of the operational way it's

168
00:08:02,999 --> 00:08:00,939
done they hold the hole open they read

169
00:08:05,909 --> 00:08:03,009
the hole so there's quite a bit of heat

170
00:08:08,069 --> 00:08:05,919
stored outside here and then if you dump

171
00:08:10,980 --> 00:08:08,079
antifreeze in there this is a lot like

172
00:08:12,540 --> 00:08:10,990
putting rock salt into crushed ice in an

173
00:08:14,519 --> 00:08:12,550
old-style ice cream maker you

174
00:08:16,290 --> 00:08:14,529
immediately drop the temperature of that

175
00:08:18,209 --> 00:08:16,300
solution you take energy out of the

176
00:08:20,699 --> 00:08:18,219
bonds in the ice and drop this

177
00:08:22,919 --> 00:08:20,709
temperature so what I'm going to do here

178
00:08:25,469 --> 00:08:22,929
is in this progression the light gray is

179
00:08:27,899 --> 00:08:25,479
the previous panels temperature profile

180
00:08:29,100 --> 00:08:27,909
and the black one is the current one so

181
00:08:31,649 --> 00:08:29,110
you drop this

182
00:08:32,939 --> 00:08:31,659
you put drop the antifreeze in you

183
00:08:35,159 --> 00:08:32,949
immediately lower the temperature of

184
00:08:37,709 --> 00:08:35,169
this but you've still got this warm ice

185
00:08:40,439 --> 00:08:37,719
outside and this ice is above the

186
00:08:43,409 --> 00:08:40,449
temperature that this stuff wants to

187
00:08:44,939 --> 00:08:43,419
dissolve so it starts to eat out it

188
00:08:48,600 --> 00:08:44,949

starts to erode the whole wall and as

189
00:08:51,949 --> 00:08:48,610
long as there is ice that is in a sense

190
00:08:54,240 --> 00:08:51,959
to warm out here this erosion continues

191
00:08:58,019 --> 00:08:54,250
till you get to a situation like this

192
00:09:00,019 --> 00:08:58,029
and now the problem arises that you

193
00:09:02,069 --> 00:09:00,029
start to freeze back and you exclude

194
00:09:02,580 --> 00:09:02,079
antifreeze back into the hole but that

195
00:09:04,050 --> 00:09:02,590
Malec

196
00:09:06,090 --> 00:09:04,060
Hiller diffusion the chemical diffusion

197
00:09:08,250 --> 00:09:06,100
is much slower than the temperature

198
00:09:09,990 --> 00:09:08,260
diffusion so you end up with a lot of

199
00:09:11,700 --> 00:09:10,000
antifreeze here not so much there but

200
00:09:19,230 --> 00:09:11,710
it's cold everywhere so you start to

201
00:09:21,240 --> 00:09:19,240
form slush in this hole aha a melt probe

202
00:09:23,700 --> 00:09:21,250
has a natural advantage in this

203
00:09:26,070 --> 00:09:23,710
situation because if you go down at

204
00:09:27,750 --> 00:09:26,080
meters per hour and notice I'm saying

205
00:09:29,790 --> 00:09:27,760
meters per hour not centimeters per hour

206
00:09:32,120 --> 00:09:29,800
just sometimes what we discuss in the

207
00:09:34,290 --> 00:09:32,130
planetary context because of power

208
00:09:35,820 --> 00:09:34,300
restrictions but if you go down to

209
00:09:38,520 --> 00:09:35,830
meters per hour you heat up much less

210
00:09:40,770 --> 00:09:38,530
ice and you don't have to keep things

211
00:09:42,810 --> 00:09:40,780
open like you do in hot water drilling

212
00:09:44,760 --> 00:09:42,820
so you you have a natural advantage

213
00:09:47,820 --> 00:09:44,770

you've put you've stored much less heat

214
00:09:49,710 --> 00:09:47,830
out here now you put in this antifreeze

215
00:09:52,380 --> 00:09:49,720
but you can put it in pretty quickly

216
00:09:55,170 --> 00:09:52,390
behind the probe and so you greatly

217
00:09:57,030 --> 00:09:55,180
limit this area and so when you get over

218
00:10:02,880 --> 00:09:57,040
here you have a much more even

219
00:10:05,190 --> 00:10:02,890
antifreeze distribution and so that's

220
00:10:06,810 --> 00:10:05,200
why we think that we can get away

221
00:10:09,810 --> 00:10:06,820
without making slush and we tested this

222
00:10:11,910 --> 00:10:09,820
first in the laboratory this is case we

223
00:10:14,370 --> 00:10:11,920
put some red food coloring in the water

224
00:10:17,220 --> 00:10:14,380
so that you could see it but the the

225
00:10:19,980 --> 00:10:17,230
hole in this laboratory block refreezes

226
00:10:21,990 --> 00:10:19,990
symmetrically and then we stopped it

227
00:10:23,760 --> 00:10:22,000
with ethanol and we didn't make slush

228
00:10:26,190 --> 00:10:23,770
but in the laboratory we had a hard time

229
00:10:29,670 --> 00:10:26,200
to keep the slush in the hole the ice

230
00:10:31,620 --> 00:10:29,680
block cracked so we have gone on to test

231
00:10:33,990 --> 00:10:31,630
this at an ice drilling program test

232
00:10:36,810 --> 00:10:34,000
facility that's an NSF sponsored test

233
00:10:40,020 --> 00:10:36,820
facility in Madison Wisconsin with a

234
00:10:42,270 --> 00:10:40,030
full-scale ice diver so you see here

235
00:10:45,510 --> 00:10:42,280
this this is the thing that is used to

236
00:10:47,430 --> 00:10:45,520
inject the ethanol there's a this is the

237
00:10:48,840 --> 00:10:47,440
top of the ice diver there's a melt head

238
00:10:51,000 --> 00:10:48,850

there that's conical in case there is

239
00:10:54,000 --> 00:10:51,010
some refreezing so we can melt and come

240
00:10:56,850 --> 00:10:54,010
back out the ice columns 14 meters high

241
00:10:59,550 --> 00:10:56,860
we injected ethanol at 0 °c during the

242
00:11:03,240 --> 00:10:59,560
descent we got temperature measurements

243
00:11:04,950 --> 00:11:03,250
along the cable and the upshot was that

244
00:11:08,160 --> 00:11:04,960
we got down the tip of the probe was at

245
00:11:10,020 --> 00:11:08,170
8 meters depth we know that there wasn't

246
00:11:13,560 --> 00:11:10,030
slush in the hole because we sampled it

247
00:11:15,970 --> 00:11:13,570
with a cup so we brought up liquid from

248
00:11:18,040 --> 00:11:15,980
various depths it was all clear

249
00:11:19,570 --> 00:11:18,050
when we turned the temperature down in

250
00:11:21,280 --> 00:11:19,580
the hole we could make slush so we could

251
00:11:23,050 --> 00:11:21,290
compare to that so we know that it was

252
00:11:27,640 --> 00:11:23,060
clear when we sampled it and then we

253
00:11:29,350 --> 00:11:27,650
recovered the probe and this is the

254
00:11:32,950 --> 00:11:29,360
temperature data so there's some cooling

255
00:11:34,180 --> 00:11:32,960
near the top it was minus 20 in Madison

256
00:11:38,440 --> 00:11:34,190
at the time that we did this last

257
00:11:40,990 --> 00:11:38,450
February but over most of the distance

258
00:11:43,180 --> 00:11:41,000
between the top of the column and the

259
00:11:46,290 --> 00:11:43,190
probe about the top of the probe is

260
00:11:48,610 --> 00:11:46,300
about minus 6 meters or 6 meters depth

261
00:11:52,720 --> 00:11:48,620
with temperatures between minus 6 and

262
00:11:58,510 --> 00:11:52,730
minus 8 so we have clear liquid at minus

263
00:12:01,690 --> 00:11:58,520

7 or so C without making slush so the

264
00:12:05,440 --> 00:12:01,700
upshot is that we think it's important

265
00:12:08,500 --> 00:12:05,450
to explore these earth analogs we think

266
00:12:10,330 --> 00:12:08,510
that we can demonstrate reliable

267
00:12:13,080 --> 00:12:10,340
operation to hundreds of meters of depth

268
00:12:15,250 --> 00:12:13,090
but we are we need to develop this

269
00:12:17,670 --> 00:12:15,260
recoverability to explore those earth

270
00:12:20,920 --> 00:12:17,680
analogs in a way that will pass muster

271
00:12:24,330 --> 00:12:20,930
and the prospect is for penetration two

272
00:12:33,790 --> 00:12:24,340
kilometers depth with a small probe

273
00:12:42,560 --> 00:12:33,800
thank you all right we have time for a

274
00:12:48,870 --> 00:12:46,140
hi I'm Kate Kraft um really cool um

275
00:12:50,400 --> 00:12:48,880
technology have you and this wasn't part

276
00:12:52,470 --> 00:12:50,410
of your talk but I'm curious about what

277
00:12:53,700 --> 00:12:52,480
are the sampling kind of technologies

278
00:12:56,790 --> 00:12:53,710
you've been looking at can you just

279
00:12:59,250 --> 00:12:56,800
speak to that for sure

280
00:13:03,000 --> 00:12:59,260
so what we're presently doing and

281
00:13:06,270 --> 00:13:03,010
working some kinks out of is to use a

282
00:13:10,140 --> 00:13:06,280
port on the side of the vehicle and a

283
00:13:11,280 --> 00:13:10,150
peristaltic pump so that's a pump that's

284
00:13:13,920 --> 00:13:11,290
commonly used in medical applications

285
00:13:15,570 --> 00:13:13,930
for instance it allows you to sterilize

286
00:13:16,890 --> 00:13:15,580
the tube that goes through the pump and

287
00:13:19,260 --> 00:13:16,900
you and the rest of the pump never

288
00:13:25,440 --> 00:13:19,270

touches the fluid and we put that into a

289
00:13:27,570 --> 00:13:25,450
bag that we autoclave and yeah we

290
00:13:30,030 --> 00:13:27,580
present that with the present size we

291
00:13:32,660 --> 00:13:30,040
have two of those units and they they

292
00:13:35,970 --> 00:13:32,670
each acquire about 150 mils of sample

293
00:13:37,770 --> 00:13:35,980
but as I say we were we have been

294
00:13:39,660 --> 00:13:37,780
exercising that in the field including

295
00:13:42,570 --> 00:13:39,670
most recently in May on Eastern glacier

296
00:13:47,400 --> 00:13:42,580
in Washington State we're still working

297
00:13:49,500 --> 00:13:47,410
on getting it working just right my

298
00:13:52,380 --> 00:13:49,510
concern was are you prevent

299
00:13:54,600 --> 00:13:52,390
contamination now just organizations but

300
00:13:55,860 --> 00:13:54,610
also contamination control and bio

301
00:14:00,780 --> 00:13:55,870
monitoring

302
00:14:02,490 --> 00:14:00,790
yes yes very much so actually caleb is

303
00:14:09,480 --> 00:14:02,500
in the back maybe it would you like to

304
00:14:11,940 --> 00:14:09,490
address that Caleb the question is how

305
00:14:14,070 --> 00:14:11,950
are we addressing forward contamination

306
00:14:15,780 --> 00:14:14,080
and I thought maybe you talked about the

307
00:14:18,120 --> 00:14:15,790
the doping and cleaning and the Ricoh

308
00:14:19,890 --> 00:14:18,130
yeah yeah so we have a protocol we use

309
00:14:22,530 --> 00:14:19,900
for cleaning it before we go into the

310
00:14:23,940 --> 00:14:22,540
ice and we've also done some laboratory

311
00:14:25,350 --> 00:14:23,950
tests where we test the dragging of

312
00:14:27,870 --> 00:14:25,360
materials in the ice as the probe

313
00:14:30,750 --> 00:14:27,880

descends and we're working on some more

314
00:14:32,970 --> 00:14:30,760
dye testing to kind of incorporate that

315
00:14:35,220 --> 00:14:32,980
with the ethanol as we just hit the rice

316
00:14:39,290 --> 00:14:35,230
to look at mixing between possible

317
00:14:41,670 --> 00:14:39,300
liquid reservoirs in the system but the

318
00:14:43,230 --> 00:14:41,680
cleaning the exterior cleaning that

319
00:14:45,030 --> 00:14:43,240
Caleb's alluding to is something that

320
00:14:47,340 --> 00:14:45,040
jill mikake developed first in

321
00:14:50,579 --> 00:14:47,350
connection with the i small i small the

322
00:14:52,439 --> 00:14:50,589
german melt probe at Taylor glacier in

323
00:14:55,119 --> 00:14:52,449
in the East End

324
00:14:59,679 --> 00:14:55,129
so and we I mean you have some very nice

325
00:15:01,840 --> 00:14:59,689
numbers about floors right yeah yeah you

326
00:15:03,970 --> 00:15:01,850
come talk to you yeah okay we'll let

327
00:15:06,280 --> 00:15:03,980
everybody get to lunch thanks again to