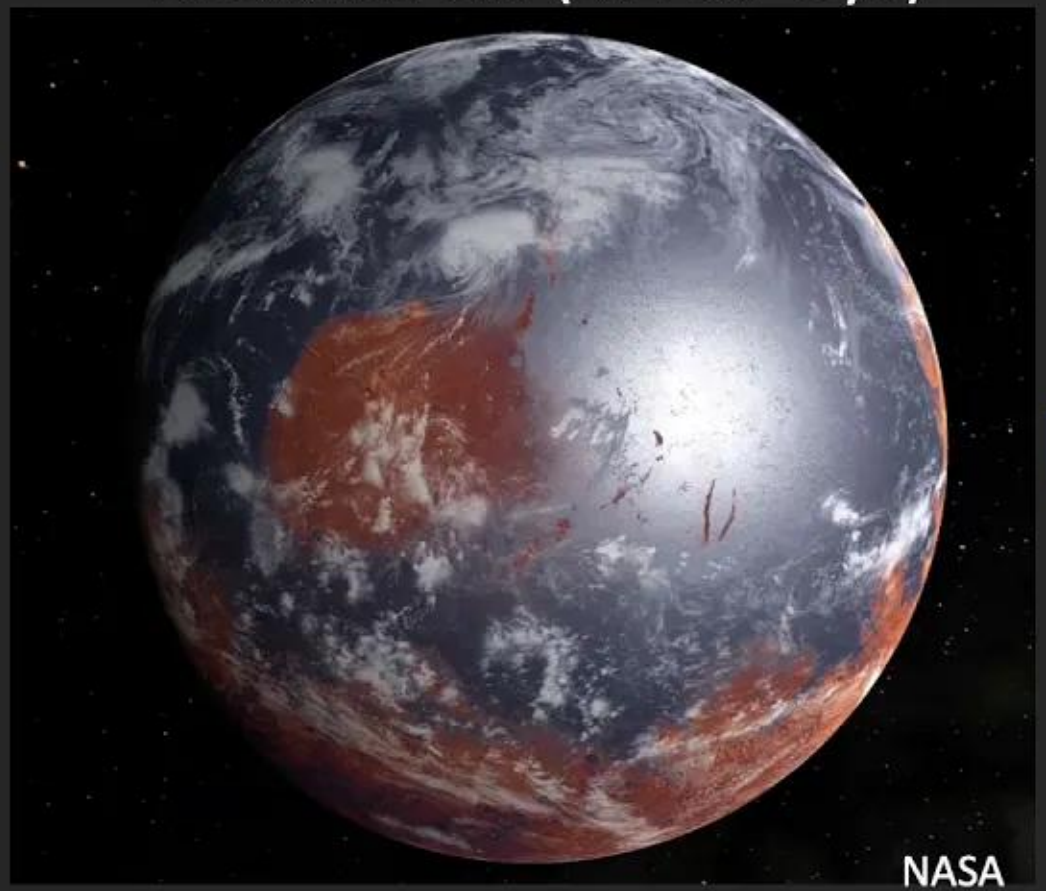
Noachian era (4.1-3.7 Gya)



- Warm?
- Wet
- Near-neutral pH

Hesperian era (3.7–3.1 Gya)

- Colder
- Dryer
- Acidic pH

1
00:00:04,470 --> 00:00:02,629
hi my name is taylor plattner and i will

2
00:00:06,389 --> 00:00:04,480
be talking about identifying field sites

3
00:00:08,390 --> 00:00:06,399
that have high biosignature preservation

4
00:00:11,509 --> 00:00:08,400
potential in planetary analog brand

5
00:00:14,709 --> 00:00:13,030
mars is proposed to have undergone a

6
00:00:16,390 --> 00:00:14,719
shift from a relatively water-rich world

7
00:00:17,910 --> 00:00:16,400
with neutral ph toward a more arid

8
00:00:19,750 --> 00:00:17,920
environment that became dominated by

9
00:00:21,189 --> 00:00:19,760
saline and acidic waters induced by

10
00:00:23,029 --> 00:00:21,199
extensive weathering of the basaltic

11
00:00:24,550 --> 00:00:23,039
bedrock this is marked in the rock

12
00:00:26,310 --> 00:00:24,560
record by shift from clay-dominated

13
00:00:27,910 --> 00:00:26,320

rocks to sulfate-rich minerals and opal

14
00:00:29,509 --> 00:00:27,920
in silica

15
00:00:31,830 --> 00:00:29,519
and from the various aqueous minerals

16
00:00:32,870 --> 00:00:31,840
images detected many locations on mars

17
00:00:34,229 --> 00:00:32,880
show evidence of the customary

18
00:00:36,389 --> 00:00:34,239
environments that indicate diverse

19
00:00:37,350 --> 00:00:36,399
aqueous conditions and as i talk about

20
00:00:38,310 --> 00:00:37,360
like history environments throughout

21
00:00:40,709 --> 00:00:38,320
this talk

22
00:00:43,510 --> 00:00:40,719
all i mean when i say liquestrian is

23
00:00:45,110 --> 00:00:43,520
being associated or related to lakes

24
00:00:46,709 --> 00:00:45,120
and if you can imagine

25
00:00:48,790 --> 00:00:46,719
various equestrian environments across

26
00:00:50,950 --> 00:00:48,800
the surface of mars in the past during

27
00:00:51,990 --> 00:00:50,960
the nowakian era the problem with

28
00:00:53,990 --> 00:00:52,000
understanding these little customer

29
00:00:55,750 --> 00:00:54,000
environments is that we don't know how

30
00:00:57,189 --> 00:00:55,760
truly habitable these environments

31
00:00:58,709 --> 00:00:57,199
really were

32
00:01:01,110 --> 00:00:58,719
because much remains to be understood

33
00:01:02,790 --> 00:01:01,120
about the early environmental conditions

34
00:01:05,270 --> 00:01:02,800
on mars

35
00:01:07,750 --> 00:01:05,280
in addition we also don't know how this

36
00:01:09,990 --> 00:01:07,760
transition from wet to dry affected the

37
00:01:12,070 --> 00:01:10,000
preservation of potential biomarkers so

38
00:01:13,270 --> 00:01:12,080

much remains to be understood about

39
00:01:15,749 --> 00:01:13,280
early mars

40
00:01:17,590 --> 00:01:15,759
and its environmental conditions and the

41
00:01:20,870 --> 00:01:17,600
preservation of potential biomarkers and

42
00:01:22,469 --> 00:01:20,880
these customer environments

43
00:01:24,469 --> 00:01:22,479
we are slowly learning what early mars

44
00:01:26,310 --> 00:01:24,479
was like from various rover missions

45
00:01:28,550 --> 00:01:26,320
that explored past water environments on

46
00:01:31,429 --> 00:01:28,560
mars such as spirit opportunity

47
00:01:32,870 --> 00:01:31,439
curiosity and now perseverance from the

48
00:01:34,789 --> 00:01:32,880
various images that have been returned

49
00:01:36,630 --> 00:01:34,799
to us from these river missions it's

50
00:01:37,749 --> 00:01:36,640
real lake beds that are geochemically

51
00:01:39,670 --> 00:01:37,759
complex

52
00:01:41,510 --> 00:01:39,680
for example hematite blueberries that

53
00:01:44,230 --> 00:01:41,520
were imaged by opportunity and

54
00:01:46,469 --> 00:01:44,240
cross-bedding images seen by curiosity

55
00:01:47,910 --> 00:01:46,479
and from these various images

56
00:01:50,230 --> 00:01:47,920
it indicates that the feature that you

57
00:01:52,469 --> 00:01:50,240
see on the surface of mars had to have

58
00:01:55,590 --> 00:01:52,479
had long-term interactions with water to

59
00:01:58,709 --> 00:01:55,600
produce the features seen here

60
00:02:00,389 --> 00:01:58,719
and on earth we know when you have these

61
00:02:02,550 --> 00:02:00,399
long-term interactions with water and

62
00:02:04,310 --> 00:02:02,560
rock the composition of your surface

63
00:02:07,109 --> 00:02:04,320

water and ground water is largely

64
00:02:08,790 --> 00:02:07,119
controlled by the reactions of water

65
00:02:10,869 --> 00:02:08,800
with rock and minerals that it's

66
00:02:13,910 --> 00:02:10,879
associated with and so these water rock

67
00:02:15,589 --> 00:02:13,920
processes can influence the ph salinity

68
00:02:17,510 --> 00:02:15,599
water activity

69
00:02:21,030 --> 00:02:17,520
and bulk chemistry

70
00:02:23,430 --> 00:02:21,040
of your water and so these water

71
00:02:25,670 --> 00:02:23,440
reactions are really important in terms

72
00:02:27,510 --> 00:02:25,680
of habitability and how this could

73
00:02:29,030 --> 00:02:27,520
affect the preservation of potential

74
00:02:30,710 --> 00:02:29,040
biomarkers

75
00:02:33,750 --> 00:02:30,720
and on mars we only can look at the

76
00:02:36,229 --> 00:02:33,760
rocks that were influenced by lake water

77
00:02:37,830 --> 00:02:36,239
however with analog lakes on earth such

78
00:02:39,910 --> 00:02:37,840
as the western australia transiting

79
00:02:42,229 --> 00:02:39,920
lakes we can actually understand these

80
00:02:45,270 --> 00:02:42,239
water rock processes and understand how

81
00:02:47,110 --> 00:02:45,280
habitable these environments were

82
00:02:49,509 --> 00:02:47,120
and how it could potentially preserve

83
00:02:51,589 --> 00:02:49,519
biomarkers over time by looking at these

84
00:02:53,509 --> 00:02:51,599
analog lakes that are going through

85
00:02:55,589 --> 00:02:53,519
these active wet dry cycles and so we

86
00:02:58,550 --> 00:02:55,599
can actually understand

87
00:03:00,630 --> 00:02:58,560
more about these water rock processes

88
00:03:02,229 --> 00:03:00,640

from these custom environments we know

89
00:03:05,270 --> 00:03:02,239
as they go through a dry stage that they

90
00:03:07,190 --> 00:03:05,280
evaporate out various minerals such as

91
00:03:09,030 --> 00:03:07,200
gypsum and halite and i'm focusing on

92
00:03:10,790 --> 00:03:09,040
gypsum and halite in this talk because

93
00:03:13,910 --> 00:03:10,800
the analog lakes i'm talking about are

94
00:03:15,830 --> 00:03:13,920
either halite or gypsum dominated

95
00:03:17,190 --> 00:03:15,840
and as we know when these lakes go

96
00:03:19,270 --> 00:03:17,200
through dry states they've evaporated

97
00:03:21,589 --> 00:03:19,280
out these minerals and when they do this

98
00:03:25,350 --> 00:03:21,599
they can entomb bias signatures

99
00:03:29,030 --> 00:03:27,750
various evaporites have been documented

100
00:03:30,309 --> 00:03:29,040
to preserve

101
00:03:32,309 --> 00:03:30,319
cells or

102
00:03:33,990 --> 00:03:32,319
molecules for upwards of thousands to

103
00:03:36,309 --> 00:03:34,000
millions of years

104
00:03:37,830 --> 00:03:36,319
and this is just an example on the left

105
00:03:40,550 --> 00:03:37,840
of preservation and gypsum and on the

106
00:03:42,470 --> 00:03:40,560
right is preservation and halite so

107
00:03:44,390 --> 00:03:42,480
we can identify these the customer

108
00:03:47,830 --> 00:03:44,400
environments from orbit by identifying

109
00:03:50,869 --> 00:03:47,840
either gypsum or halite

110
00:03:53,589 --> 00:03:50,879
remotely and when we do this

111
00:03:55,429 --> 00:03:53,599
in turn we can also identify areas that

112
00:03:57,429 --> 00:03:55,439
have a high biosignature preservation

113
00:03:59,030 --> 00:03:57,439

potential

114
00:04:00,070 --> 00:03:59,040
the analog lakes that i'm interested in

115
00:04:01,350 --> 00:04:00,080
are called the western australia

116
00:04:02,869 --> 00:04:01,360
transient lakes

117
00:04:05,990 --> 00:04:02,879
and they're really unique to mars in

118
00:04:07,910 --> 00:04:06,000
terms of their age and composition

119
00:04:09,910 --> 00:04:07,920
these host rocks that the lakes sit on

120
00:04:12,869 --> 00:04:09,920
are about the same age as the hesperian

121
00:04:14,949 --> 00:04:12,879
and novakian terrains on mars and in

122
00:04:16,550 --> 00:04:14,959
addition they have a similar composition

123
00:04:18,870 --> 00:04:16,560
to various little customer environments

124
00:04:22,310 --> 00:04:18,880
on mars such as murdani platinum and

125
00:04:25,270 --> 00:04:24,150
and in addition these lakes are also

126
00:04:27,350 --> 00:04:25,280
interesting because they have a wide

127
00:04:30,150 --> 00:04:27,360
range of geochemical conditions

128
00:04:31,990 --> 00:04:30,160
including ph salinity and temperatures

129
00:04:33,830 --> 00:04:32,000
which we think that mars could have had

130
00:04:35,590 --> 00:04:33,840
a wide range of geochemical conditions

131
00:04:37,189 --> 00:04:35,600
in the past and this image is just

132
00:04:39,749 --> 00:04:37,199
showing what these western australia

133
00:04:41,990 --> 00:04:39,759
transit legs look like

134
00:04:42,790 --> 00:04:42,000
and as you can see there's multiple of

135
00:04:44,469 --> 00:04:42,800
them

136
00:04:46,950 --> 00:04:44,479
and so what i'm going to most will be

137
00:04:49,510 --> 00:04:46,960
focusing on this talk is using remote

138
00:04:52,870 --> 00:04:49,520

sensing to inform site selection of

139
00:04:54,469 --> 00:04:52,880
these lakes so down selecting from

140
00:04:58,230 --> 00:04:54,479
hundreds of lakes

141
00:05:00,310 --> 00:04:58,240
to a small section of lakes to go sample

142
00:05:01,590 --> 00:05:00,320
in situ

143
00:05:02,950 --> 00:05:01,600
as i was saying earlier the western

144
00:05:04,870 --> 00:05:02,960
australia trains and lakes go through

145
00:05:07,830 --> 00:05:04,880
these wet dry cycles and as they do this

146
00:05:08,950 --> 00:05:07,840
the geochemical conditions change

147
00:05:10,870 --> 00:05:08,960
and so what i'm showing here is a

148
00:05:13,350 --> 00:05:10,880
schematic diagram going through each of

149
00:05:15,590 --> 00:05:13,360
the stages

150
00:05:16,790 --> 00:05:15,600
and as they do this their geochemical

151
00:05:18,790 --> 00:05:16,800
response

152
00:05:20,710 --> 00:05:18,800
to that stage and so the first one is

153
00:05:23,029 --> 00:05:20,720
the wet stage or the flooding stage in

154
00:05:25,430 --> 00:05:23,039
which all your vaporites are basically

155
00:05:27,590 --> 00:05:25,440
dissolved and

156
00:05:29,670 --> 00:05:27,600
in this stage you're going to have

157
00:05:31,670 --> 00:05:29,680
the most basic water and it's going to

158
00:05:33,430 --> 00:05:31,680
be the least saline

159
00:05:34,870 --> 00:05:33,440
and then when you slowly evaporate out

160
00:05:36,310 --> 00:05:34,880
water you're going to start to perform

161
00:05:37,909 --> 00:05:36,320
your precipitates such as halite and

162
00:05:39,749 --> 00:05:37,919
gypsum because these western style

163
00:05:41,590 --> 00:05:39,759

transients are gypsum or halite

164
00:05:42,870 --> 00:05:41,600
dominated lakes

165
00:05:44,469 --> 00:05:42,880
and when you evaporate out these

166
00:05:46,629 --> 00:05:44,479
minerals this is when you can attune

167
00:05:48,629 --> 00:05:46,639
biomarkers and this is when your ph is

168
00:05:49,670 --> 00:05:48,639
going to become more acidic and more

169
00:05:52,230 --> 00:05:49,680
saline

170
00:05:53,670 --> 00:05:52,240
and then finally in your dry stage this

171
00:05:54,710 --> 00:05:53,680
is when you've evaporated out all your

172
00:05:56,390 --> 00:05:54,720
water

173
00:05:58,710 --> 00:05:56,400
and you have these thick halite and

174
00:05:59,909 --> 00:05:58,720
gypsum beds this is when your

175
00:06:02,629 --> 00:05:59,919
late chemistries are going to be the

176
00:06:04,390 --> 00:06:02,639
most acidic and the most saline and so

177
00:06:07,270 --> 00:06:04,400
motivation for this

178
00:06:10,469 --> 00:06:07,280
is trying to identify these cycles

179
00:06:12,150 --> 00:06:10,479
from orbit so that we can

180
00:06:13,830 --> 00:06:12,160
influence our

181
00:06:16,150 --> 00:06:13,840
sampling time so that we can capture

182
00:06:18,070 --> 00:06:16,160
both the wet and the dry cycle so we can

183
00:06:20,070 --> 00:06:18,080
capture how these lakes are changing

184
00:06:22,469 --> 00:06:20,080
over time and how that is affecting

185
00:06:25,110 --> 00:06:22,479
habitability of the system

186
00:06:27,830 --> 00:06:25,120
and in turn affecting preservation of

187
00:06:31,830 --> 00:06:29,510
so how do i identify

188
00:06:34,309 --> 00:06:31,840

these wet dry cycles from orbit i did

189
00:06:36,550 --> 00:06:34,319
this by using landsat 8 data from usgs

190
00:06:39,909 --> 00:06:36,560
and i completed band ratio images

191
00:06:42,790 --> 00:06:39,919
specifically using band 5 and band 6 of

192
00:06:44,870 --> 00:06:42,800
landsat 8 because it uniquely these

193
00:06:46,070 --> 00:06:44,880
bands uniquely define the distribution

194
00:06:48,710 --> 00:06:46,080
of gypsum

195
00:06:50,070 --> 00:06:48,720
and specifically i'm focusing on gypsum

196
00:06:52,230 --> 00:06:50,080
right now because these legs are either

197
00:06:53,510 --> 00:06:52,240
halite or gypsum dominated and what

198
00:06:56,230 --> 00:06:53,520
you're seeing in this image is a

199
00:06:58,390 --> 00:06:56,240
spectrum of gypsum and

200
00:07:00,150 --> 00:06:58,400
this is showing where band 5 and band 6

201
00:07:02,309 --> 00:07:00,160
of landsat covers

202
00:07:04,390 --> 00:07:02,319
and so this band 5 is covering a highly

203
00:07:06,870 --> 00:07:04,400
a highly reflective portion of the

204
00:07:08,230 --> 00:07:06,880
gypsum spectrum and the band 6 is

205
00:07:09,909 --> 00:07:08,240
covering a highly absorptive feature of

206
00:07:12,469 --> 00:07:09,919
the gypsum spectrum and when you take a

207
00:07:15,270 --> 00:07:12,479
band ratio of those two bands what

208
00:07:17,909 --> 00:07:15,280
you'll get in the return image is

209
00:07:20,309 --> 00:07:17,919
showing that the bright areas are gonna

210
00:07:21,350 --> 00:07:20,319
indicate gypsum and so that's what i'm

211
00:07:23,510 --> 00:07:21,360
gonna show

212
00:07:25,510 --> 00:07:23,520
in a couple of slides when i show my

213
00:07:28,629 --> 00:07:25,520

band ratio images

214
00:07:30,870 --> 00:07:28,639
and really quick i just wanted to show

215
00:07:32,230 --> 00:07:30,880
where these lakes were at on a map so

216
00:07:33,670 --> 00:07:32,240
all the red dots are the western

217
00:07:35,670 --> 00:07:33,680
australia transient links which are

218
00:07:37,430 --> 00:07:35,680
documented in the literature

219
00:07:41,589 --> 00:07:37,440
and

220
00:07:43,589 --> 00:07:41,599
i basically looked at all of these lakes

221
00:07:45,189 --> 00:07:43,599
over several years

222
00:07:47,270 --> 00:07:45,199
to see if i could identify whether

223
00:07:48,390 --> 00:07:47,280
they're going through wet dry cycles

224
00:07:49,830 --> 00:07:48,400
over time

225
00:07:51,510 --> 00:07:49,840
and so what you'll see in the return

226
00:07:52,869 --> 00:07:51,520
images is that the

227
00:07:56,070 --> 00:07:52,879
southern grouping of lakes acts

228
00:07:58,070 --> 00:07:56,080
differently than the rest of these lakes

229
00:07:59,909 --> 00:07:58,080
the eastern northern and central lakes

230
00:08:01,830 --> 00:07:59,919
and these are just based off

231
00:08:03,510 --> 00:08:01,840
um grouped off by their geographical

232
00:08:05,430 --> 00:08:03,520
location

233
00:08:07,110 --> 00:08:05,440
and these southern light groupings act

234
00:08:10,070 --> 00:08:07,120
differently because if you look at the

235
00:08:13,749 --> 00:08:10,080
precipitation and climate data

236
00:08:16,309 --> 00:08:13,759
this location gets more average rainfall

237
00:08:19,029 --> 00:08:16,319
than the rest of the lakes in local

238
00:08:23,589 --> 00:08:19,039

winter in australia and so that's what

239
00:08:26,950 --> 00:08:24,710
okay so what i'm going to show in the

240
00:08:29,589 --> 00:08:26,960
next couple images

241
00:08:31,670 --> 00:08:29,599
are these two subsets of lakes so on the

242
00:08:32,790 --> 00:08:31,680
left is going to be in blue

243
00:08:34,630 --> 00:08:32,800
it's going to be the southern region of

244
00:08:36,550 --> 00:08:34,640
lakes on the right and red is going to

245
00:08:38,070 --> 00:08:36,560
be this small subset of the eastern

246
00:08:39,750 --> 00:08:38,080
grouping of lakes

247
00:08:41,829 --> 00:08:39,760
so this is southern region and then this

248
00:08:44,070 --> 00:08:41,839
is the eastern region and this is just a

249
00:08:46,389 --> 00:08:44,080
color image of the lakes

250
00:08:47,750 --> 00:08:46,399
and on the top row is going to be local

251
00:08:50,630 --> 00:08:47,760
summer in western australia and the

252
00:08:52,310 --> 00:08:50,640
monroe's local winter in australia

253
00:08:53,750 --> 00:08:52,320
and what you'll see again in the

254
00:08:55,190 --> 00:08:53,760
southern region of lakes is that they

255
00:08:56,230 --> 00:08:55,200
act differently than the rest of the

256
00:08:57,509 --> 00:08:56,240
lakes

257
00:09:00,470 --> 00:08:57,519
and

258
00:09:02,790 --> 00:09:00,480
you can really see this in january

259
00:09:04,389 --> 00:09:02,800
and july and this is because in local

260
00:09:06,070 --> 00:09:04,399
summer this is when

261
00:09:07,190 --> 00:09:06,080
these lakes are going the southern

262
00:09:09,430 --> 00:09:07,200
grouping of lakes are going through a

263
00:09:11,269 --> 00:09:09,440

dry stage and then in july they're going

264
00:09:12,790 --> 00:09:11,279
through a wet stage whereas these

265
00:09:15,670 --> 00:09:12,800
eastern grouping of flakes you can't

266
00:09:20,949 --> 00:09:17,990
okay so this is the band ratio images

267
00:09:23,110 --> 00:09:20,959
that i did to indicate that gypsum was

268
00:09:24,470 --> 00:09:23,120
present again this is the southern

269
00:09:26,230 --> 00:09:24,480
region of lakes and this is the eastern

270
00:09:28,550 --> 00:09:26,240
grouping of flakes

271
00:09:31,110 --> 00:09:28,560
and this is the band ratio image not the

272
00:09:32,550 --> 00:09:31,120
color image so this is

273
00:09:34,949 --> 00:09:32,560
again local

274
00:09:37,110 --> 00:09:34,959
summer is the top row and local winner

275
00:09:39,430 --> 00:09:37,120
is the bottom row and so what you'll see

276
00:09:41,110 --> 00:09:39,440
that is different in the southern region

277
00:09:42,470 --> 00:09:41,120
of lakes rather than in the eastern

278
00:09:43,750 --> 00:09:42,480
region is that

279
00:09:45,990 --> 00:09:43,760
these southern region lakes are really

280
00:09:47,269 --> 00:09:46,000
going through a dry stage in a wet stage

281
00:09:49,350 --> 00:09:47,279
again this dry stage is when you've

282
00:09:50,630 --> 00:09:49,360
evaporated all your minerals this is

283
00:09:52,389 --> 00:09:50,640
going to be the most acidic and most

284
00:09:53,910 --> 00:09:52,399
saline whereas in the wet stage you've

285
00:09:55,750 --> 00:09:53,920
dissolved all your minerals and it's

286
00:09:58,550 --> 00:09:55,760
going to be the least saline and the

287
00:09:59,990 --> 00:09:58,560
most basic so we want to sample both of

288
00:10:01,990 --> 00:10:00,000

these times

289
00:10:03,590 --> 00:10:02,000
to understand what's happening over time

290
00:10:05,509 --> 00:10:03,600
in these western australia transient

291
00:10:06,870 --> 00:10:05,519
lakes and whereas in the eastern

292
00:10:08,389 --> 00:10:06,880
groupings of lakes you really can't tell

293
00:10:09,829 --> 00:10:08,399
what is happening

294
00:10:12,949 --> 00:10:09,839
over time whether it's going through a

295
00:10:14,710 --> 00:10:12,959
wet dry cycle or not

296
00:10:16,389 --> 00:10:14,720
based off the remote sensing results

297
00:10:18,710 --> 00:10:16,399
most of the lakes don't show the

298
00:10:20,949 --> 00:10:18,720
seasonal variations only the southern

299
00:10:22,870 --> 00:10:20,959
regions of lakes really show

300
00:10:24,870 --> 00:10:22,880
a trend as they go through these wet dry

301
00:10:26,790 --> 00:10:24,880
cycles

302
00:10:28,710 --> 00:10:26,800
and this is important when we actually

303
00:10:30,949 --> 00:10:28,720
go sample these measuring

304
00:10:33,430 --> 00:10:30,959
these lakes in situ

305
00:10:34,870 --> 00:10:33,440
so we actually get context

306
00:10:36,790 --> 00:10:34,880
when we sample

307
00:10:39,750 --> 00:10:36,800
and from these results it's really

308
00:10:41,350 --> 00:10:39,760
motivation for a second sampling season

309
00:10:42,790 --> 00:10:41,360
for the southern region of the lakes so

310
00:10:45,030 --> 00:10:42,800
we want to go to the western australia

311
00:10:47,190 --> 00:10:45,040
lakes and sample twice at different

312
00:10:49,110 --> 00:10:47,200
times and the local winter in local

313
00:10:50,790 --> 00:10:49,120

summer so that we capture these wet dry

314
00:10:51,910 --> 00:10:50,800
cycles that the southern region of lakes

315
00:10:53,750 --> 00:10:51,920
are going to

316
00:10:55,430 --> 00:10:53,760
whereas the other group of lakes such as

317
00:10:56,710 --> 00:10:55,440
central eastern and northern lakes we

318
00:11:02,230 --> 00:10:56,720
can really sample

319
00:11:06,230 --> 00:11:04,310
now to complete this work i want to

320
00:11:07,509 --> 00:11:06,240
ground truth with the spectrometer to

321
00:11:10,150 --> 00:11:07,519
identify

322
00:11:11,509 --> 00:11:10,160
gypsum and situ so that we can

323
00:11:14,630 --> 00:11:11,519
verify whether what we're seeing in the

324
00:11:16,389 --> 00:11:14,640
remote sensing images is actually gypsum

325
00:11:18,310 --> 00:11:16,399
in addition i want to further map and

326
00:11:20,710 --> 00:11:18,320
identify gypsum using the spectral angle

327
00:11:22,550 --> 00:11:20,720
mapper classification and envy

328
00:11:24,150 --> 00:11:22,560
and then lastly i want to extend present

329
00:11:25,910 --> 00:11:24,160
work

330
00:11:28,389 --> 00:11:25,920
to include

331
00:11:30,870 --> 00:11:28,399
halite by using astra data

332
00:11:32,870 --> 00:11:30,880
because you need the thermal infrared to

333
00:11:35,030 --> 00:11:32,880
identify chlorides and i'm going to do

334
00:11:37,110 --> 00:11:35,040
this by using a method developed by

335
00:11:38,710 --> 00:11:37,120
alice baldridge which was then