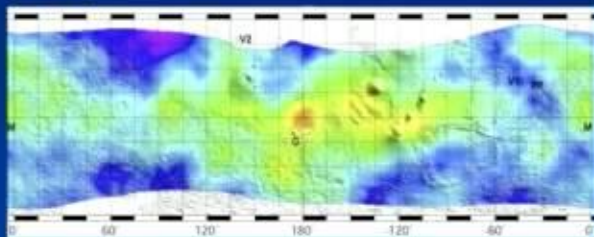




## Chlorine Distributions

- Mars has regions of high chlorine concentrations
  - Highest concentrations are coincident with the Medusa Fossae Formation (volcanic ash?)
  - Is this a product of unique alteration or unique source composition?
- Other Gamma Ray Spectrometer compositions are also useful (e.g. K/Th)



*GRS Chlorine Abundance*  
*Keller et al., 2006*



NASA  
Astrobiology  
Institute

University of Washington  
Astrobiology Seminar Series

1  
00:00:09,379 --> 00:00:06,950  
so our speaker today got his degree is

2  
00:00:12,499 --> 00:00:09,389  
bachelor sat in geological sciences at

3  
00:00:15,490 --> 00:00:12,509  
Santa Barbara and his PhD in geology at

4  
00:00:18,460 --> 00:00:15,500  
Arizona State in two thousand Josh

5  
00:00:21,170 --> 00:00:18,470  
Benfield has been actively involved in a

6  
00:00:24,380 --> 00:00:21,180  
spacecraft for some time and these

7  
00:00:27,109 --> 00:00:24,390  
include Mars Global Surveyor the 2001

8  
00:00:28,700 --> 00:00:27,119  
Mars Odyssey the Mars Explorer over the

9  
00:00:31,070 --> 00:00:28,710  
Mars Reconnaissance Orbiter and the

10  
00:00:32,659 --> 00:00:31,080  
Lunar Reconnaissance Orbiter his work

11  
00:00:35,120 --> 00:00:32,669  
especially focuses on atmospheric

12  
00:00:37,280 --> 00:00:35,130  
monitoring surface composition and

13  
00:00:39,350 --> 00:00:37,290

thermo physical properties of planetary

14

00:00:41,299 --> 00:00:39,360

surfaces he's currently a research

15

00:00:44,779 --> 00:00:41,309

assistant professor in ESS and he

16

00:00:47,810 --> 00:00:44,789

started with us last february his title

17

00:00:55,720 --> 00:00:47,820

today is a complex compositional and

18

00:00:59,540 --> 00:00:55,730

aqueous history of Mars God all right

19

00:01:06,880 --> 00:00:59,550

see if we get the light so that we can

20

00:01:06,890 --> 00:01:12,870

one of those permutations for work

21

00:01:19,740 --> 00:01:18,240

okay so yeah basically I'm trying to

22

00:01:21,450 --> 00:01:19,750

cover quite a bit of ground with this

23

00:01:24,080 --> 00:01:21,460

talk and hopefully I'll keep it general

24

00:01:25,830 --> 00:01:24,090

enough that kind of the

25

00:01:29,310 --> 00:01:25,840

interdisciplinary nature of the audience

26

00:01:30,859 --> 00:01:29,320

can follow relatively easily but yeah

27

00:01:33,389 --> 00:01:30,869

basically I wanted to talk about

28

00:01:35,520 --> 00:01:33,399

essentially the slew of surface

29

00:01:39,389 --> 00:01:35,530

compositions that we see on the surface

30

00:01:42,090 --> 00:01:39,399

of Mars and then do my best to try to

31

00:01:44,100 --> 00:01:42,100

attempt to connect that with what that

32

00:01:47,550 --> 00:01:44,110

means for the conditions on the in the

33

00:01:49,620 --> 00:01:47,560

past and what that means for the ability

34

00:01:53,730 --> 00:01:49,630

for life to be preserved and develop on

35

00:01:56,449 --> 00:01:53,740

the surface so let's just start with an

36

00:01:59,160 --> 00:01:56,459

outline of what I want to talk about

37

00:02:00,899 --> 00:01:59,170

essentially this is I wanted basically

38

00:02:04,230 --> 00:02:00,909

these are what I consider sort of four

39

00:02:06,990 --> 00:02:04,240

steps from basically collecting the data

40

00:02:10,949 --> 00:02:07,000

to trying to get at what well

41

00:02:13,259 --> 00:02:10,959

essentially why NASA is funding the

42

00:02:14,759 --> 00:02:13,269

all the Martian orbiters and Rovers to

43

00:02:17,309 --> 00:02:14,769

begin with is we're starting with

44

00:02:18,930 --> 00:02:17,319

collecting the data we're trying to get

45

00:02:20,220 --> 00:02:18,940

at surface composition and by the way

46

00:02:21,660 --> 00:02:20,230

I'm going to focus on surface

47

00:02:23,309 --> 00:02:21,670

composition there's also lots of

48

00:02:24,690 --> 00:02:23,319

morphological studies with cameras and

49

00:02:27,120 --> 00:02:24,700

other things that I'm getting alerts we

50

00:02:29,430 --> 00:02:27,130

not talk about from the surface

51  
00:02:31,199 --> 00:02:29,440  
compositions we reason we want to know

52  
00:02:33,330 --> 00:02:31,209  
these things is basically to get at the

53  
00:02:34,770 --> 00:02:33,340  
formation conditions basically you know

54  
00:02:37,050 --> 00:02:34,780  
if you see a limestone it means his

55  
00:02:39,180 --> 00:02:37,060  
father there basalt and it means it was

56  
00:02:42,059 --> 00:02:39,190  
a volcano obviously it gets a lot more

57  
00:02:44,490 --> 00:02:42,069  
complex than that and then basically

58  
00:02:46,800 --> 00:02:44,500  
going from these conditions to linking

59  
00:02:51,030 --> 00:02:46,810  
those conditions to the habitability and

60  
00:02:53,550 --> 00:02:51,040  
preservation potential on Mars and so

61  
00:02:55,559 --> 00:02:53,560  
you know in the NASA's mantra is

62  
00:02:57,059 --> 00:02:55,569  
basically let's follow the water we're

63  
00:02:58,410 --> 00:02:57,069

trying to follow the water back to the

64

00:03:00,349 --> 00:02:58,420

conditions back to trying to figure out

65

00:03:03,660 --> 00:03:00,359

whether or not life actually ever

66

00:03:08,910 --> 00:03:03,670

developed at one point and or still

67

00:03:11,039 --> 00:03:08,920

exist on the planet today so taking

68

00:03:13,890 --> 00:03:11,049

these four steps I want to go over just

69

00:03:17,250 --> 00:03:13,900

a brief up the brief description of sort

70

00:03:19,620 --> 00:03:17,260

of where are we now and basically you

71

00:03:21,719 --> 00:03:19,630

can go from step one well with I'm

72

00:03:23,819 --> 00:03:21,729

calling step one down to here and you'll

73

00:03:25,850 --> 00:03:23,829

probably pretty much gets a little bit

74

00:03:28,520 --> 00:03:25,860

less that well

75

00:03:30,110 --> 00:03:28,530

amount of knowledge or data or

76

00:03:31,850 --> 00:03:30,120

understanding basically gets less and

77

00:03:34,070 --> 00:03:31,860

less as we go from the beginning steps

78

00:03:36,200 --> 00:03:34,080

down to the more complicated ones but

79

00:03:38,510 --> 00:03:36,210

clicking accurate data this is basically

80

00:03:39,950 --> 00:03:38,520

a whole bunch of NASA acronyms and you

81

00:03:41,690 --> 00:03:39,960

can write a whole paragraph full of

82

00:03:44,090 --> 00:03:41,700

acronyms but yeah we have we've

83

00:03:46,910 --> 00:03:44,100

collected a lot of data Mars Global

84

00:03:51,050 --> 00:03:46,920

Surveyor Mars Odyssey Martha Mars

85

00:03:52,490 --> 00:03:51,060

Express Mars exploration Rovers and Mars

86

00:03:54,470 --> 00:03:52,500

Reconnaissance Orbiter all have

87

00:03:56,120 --> 00:03:54,480

instruments on those spacecraft that

88

00:03:59,150 --> 00:03:56,130

help us try to understand what the

89

00:04:00,770 --> 00:03:59,160

composition of the surface is and

90

00:04:02,960 --> 00:04:00,780

they've all been highly successful

91

00:04:06,320 --> 00:04:02,970

they've collected terabytes and

92

00:04:08,300 --> 00:04:06,330

terabytes of data and there's basically

93

00:04:11,660 --> 00:04:08,310

there's lots of data there with lots of

94

00:04:13,880 --> 00:04:11,670

potential taking the next step well

95

00:04:16,009 --> 00:04:13,890

we've got the data how do we how are we

96

00:04:19,039 --> 00:04:16,019

what's where are we with determining

97

00:04:20,539 --> 00:04:19,049

surface composition and sure there's

98

00:04:22,099 --> 00:04:20,549

many details that are still being worked

99

00:04:24,230 --> 00:04:22,109

out there's probably many discoveries

100

00:04:25,370 --> 00:04:24,240

still left to be made but

101  
00:04:28,040 --> 00:04:25,380  
many discoveries have already been made

102  
00:04:30,670 --> 00:04:28,050  
in the past decade basically since Mars

103  
00:04:32,600 --> 00:04:30,680  
Global Surveyor went into orbit our

104  
00:04:37,430 --> 00:04:32,610  
understanding of the composition of the

105  
00:04:41,390 --> 00:04:37,440  
Martian surface has changed in a big way

106  
00:04:43,430 --> 00:04:41,400  
probably several times over now okay

107  
00:04:45,320 --> 00:04:43,440  
getting a little bit more specific let's

108  
00:04:46,790 --> 00:04:45,330  
take these surface compositions and try

109  
00:04:48,710 --> 00:04:46,800  
to interpret what the formation

110  
00:04:50,930 --> 00:04:48,720  
conditions what conditions were present

111  
00:04:53,150 --> 00:04:50,940  
on Mars at the time and that's actually

112  
00:04:55,190 --> 00:04:53,160  
more difficult of course and the

113  
00:04:56,750 --> 00:04:55,200

hypotheses have hypotheses have been

114

00:04:59,060 --> 00:04:56,760

forwarded and links are starting to be

115

00:05:00,980 --> 00:04:59,070

made but i would i would argue that

116

00:05:03,500 --> 00:05:00,990

basically our understanding is getting

117

00:05:04,940 --> 00:05:03,510

more and more vague and then finally the

118

00:05:07,370 --> 00:05:04,950

final step of linking those conditions

119

00:05:09,230 --> 00:05:07,380

that habitability the way I would

120

00:05:11,290 --> 00:05:09,240

describe is it's no longer exclusively

121

00:05:13,580 --> 00:05:11,300

the realm of wild speculation

122

00:05:16,120 --> 00:05:13,590

essentially there's actually good work

123

00:05:18,620 --> 00:05:16,130

that's starting to be done there but the

124

00:05:24,640 --> 00:05:18,630

amount of unknown versus the amount of

125

00:05:27,350 --> 00:05:24,650

known it's it's a very large ratio so

126

00:05:30,080 --> 00:05:27,360

let's start with the measurements and

127

00:05:32,360 --> 00:05:30,090

i'll describe hopefully very briefly the

128

00:05:36,100 --> 00:05:32,370

measurement techniques and i'll focus

129

00:05:39,290 --> 00:05:36,110

mostly on essentially the spectroscopy

130

00:05:41,059 --> 00:05:39,300

my basically my expertise is

131

00:05:43,369 --> 00:05:41,069

and thermal infrared spectroscopy and

132

00:05:44,990 --> 00:05:43,379

basically a lot of the compositions that

133

00:05:46,430 --> 00:05:45,000

we know about the surface of Mars today

134

00:05:48,649 --> 00:05:46,440

are visible through a thermal infrared

135

00:05:51,249 --> 00:05:48,659

spectroscopy both from orbit and in situ

136

00:05:55,219 --> 00:05:51,259

and that's gonna be the primary focus

137

00:05:56,629 --> 00:05:55,229

presented here but one thing I wanted to

138

00:05:59,149 --> 00:05:56,639

make sure I pointed out is that other

139

00:06:02,080 --> 00:05:59,159

measurements have been made and they

140

00:06:04,279 --> 00:06:02,090

made it very important contributions

141

00:06:06,110 --> 00:06:04,289

basically mössbauer spectroscopy which

142

00:06:08,779 --> 00:06:06,120

the mastaba spectrometer is on the

143

00:06:11,899 --> 00:06:08,789

instrument deployment device on the Mars

144

00:06:13,520 --> 00:06:11,909

exploration Rovers has given us vast

145

00:06:16,610 --> 00:06:13,530

amounts of information on the iron

146

00:06:18,770 --> 00:06:16,620

mineralogy of Martian surface so that's

147

00:06:20,300 --> 00:06:18,780

made a very important contribution that

148

00:06:22,939 --> 00:06:20,310

I'm not going to talk about in detail

149

00:06:24,920 --> 00:06:22,949

and then there's gamma ray Neutron alpha

150

00:06:26,649 --> 00:06:24,930

proton x-ray spectroscopy basically

151  
00:06:29,980 --> 00:06:26,659  
those give you elemental compositions

152  
00:06:32,119 --> 00:06:29,990  
either from orbit or Institute and

153  
00:06:34,279 --> 00:06:32,129  
basically with those compositions you

154  
00:06:36,800 --> 00:06:34,289  
can infer surface Meteorology's as well

155  
00:06:39,290 --> 00:06:36,810  
and they've made really important

156  
00:06:40,490 --> 00:06:39,300  
contributions as well the big point here

157  
00:06:41,510 --> 00:06:40,500  
though is that no single measurement

158  
00:06:43,760 --> 00:06:41,520  
technique provides a complete

159  
00:06:45,019 --> 00:06:43,770  
mineralogical picture you have to look

160  
00:06:46,420 --> 00:06:45,029  
at something from a variety of

161  
00:06:49,249 --> 00:06:46,430  
perspectives in order to get at

162  
00:06:51,439 --> 00:06:49,259  
basically what what is the mineralogy of

163  
00:06:54,019 --> 00:06:51,449

the surface and some techniques are

164

00:06:56,149 --> 00:06:54,029

better under fine grained for fine

165

00:06:59,330 --> 00:06:56,159

particulates others are for better for

166

00:07:00,860 --> 00:06:59,340

course particulates warm temperatures

167

00:07:02,240 --> 00:07:00,870

lots of sunlight basically different

168

00:07:04,189 --> 00:07:02,250

conditions are better for different

169

00:07:06,469 --> 00:07:04,199

instrument techniques and so even though

170

00:07:07,730 --> 00:07:06,479

the principal investigator of either any

171

00:07:08,570 --> 00:07:07,740

one of these instruments will tell you

172

00:07:10,519 --> 00:07:08,580

it's the greatest thing since sliced

173

00:07:12,490 --> 00:07:10,529

bread and that it will tell you

174

00:07:15,019 --> 00:07:12,500

everything you wanted to know about Mars

175

00:07:16,730 --> 00:07:15,029

basically it's the it's a combination of

176  
00:07:22,730 --> 00:07:16,740  
the measurements that helps build up a

177  
00:07:24,170 --> 00:07:22,740  
good picture so let's start with thermal

178  
00:07:26,360 --> 00:07:24,180  
infrared spectroscopy and this is

179  
00:07:30,709 --> 00:07:26,370  
basically the the one slide background

180  
00:07:32,749 --> 00:07:30,719  
and this is where I focused much of my

181  
00:07:35,350 --> 00:07:32,759  
work we've looking at fifty to fifty

182  
00:07:37,490 --> 00:07:35,360  
Mike a 5 to 50 micron wavelength

183  
00:07:39,110 --> 00:07:37,500  
basically we're looking at energy that's

184  
00:07:40,939 --> 00:07:39,120  
being emitted from the surface it's not

185  
00:07:43,999 --> 00:07:40,949  
reflected light it's emitted light and

186  
00:07:45,980 --> 00:07:44,009  
if we look at emissivity basically

187  
00:07:47,810 --> 00:07:45,990  
different the way I put is basically

188  
00:07:50,930 --> 00:07:47,820

different materials glow different

189

00:07:52,340 --> 00:07:50,940

colors in a thermal infrared and these

190

00:07:54,680 --> 00:07:52,350

are

191

00:07:56,780 --> 00:07:54,690

what a variety of different rock-forming

192

00:07:58,280 --> 00:07:56,790

minerals from quartz the feldspar clay

193

00:07:59,990 --> 00:07:58,290

Erickson Anala be we're going from

194

00:08:02,210 --> 00:08:00,000

isolated tetrahedra of framework

195

00:08:05,420 --> 00:08:02,220

silicates as well as carbonates and

196

00:08:08,180 --> 00:08:05,430

sulfates and you'll notice that the

197

00:08:10,430 --> 00:08:08,190

squiggly lines have are very distinct

198

00:08:12,770 --> 00:08:10,440

between the different materials and so

199

00:08:14,870 --> 00:08:12,780

basically these different materials have

200

00:08:17,570 --> 00:08:14,880

their characteristic fingerprints that

201  
00:08:20,990 --> 00:08:17,580  
you can use to identify what the

202  
00:08:22,250 --> 00:08:21,000  
composition of the surface is so most

203  
00:08:23,930 --> 00:08:22,260  
rock-forming minerals have these

204  
00:08:27,230 --> 00:08:23,940  
distinctive absorptions in the thermal

205  
00:08:29,030 --> 00:08:27,240  
infrared and one of the nice nice

206  
00:08:30,770 --> 00:08:29,040  
properties of this is at the if you're

207  
00:08:32,770 --> 00:08:30,780  
looking at a coarse particulate surface

208  
00:08:36,170 --> 00:08:32,780  
like sand or rocks or whatever

209  
00:08:37,850 --> 00:08:36,180  
essentially the there the contribution

210  
00:08:39,560 --> 00:08:37,860  
to your measured spectrum combines in a

211  
00:08:41,779 --> 00:08:39,570  
linear manner so you can basically use

212  
00:08:43,670 --> 00:08:41,789  
that to deke involve your measured

213  
00:08:46,370 --> 00:08:43,680

spectrum to back out the abundance of

214

00:08:49,670 --> 00:08:46,380

each of the constituents so if you had a

215

00:08:52,490 --> 00:08:49,680

basalt for example you'd have basically

216

00:08:54,230 --> 00:08:52,500

the the p rock scene and the feldspar

217

00:08:55,520 --> 00:08:54,240

and the olivene would combine in a

218

00:08:57,980 --> 00:08:55,530

linear manner and you could take that

219

00:08:59,630 --> 00:08:57,990

spectrum of that basalt and deke involve

220

00:09:01,600 --> 00:08:59,640

the waiting's of each of these spectra

221

00:09:04,310 --> 00:09:01,610

to get at the the abundance of them of

222

00:09:06,980 --> 00:09:04,320

course that has many many caveats and

223

00:09:10,610 --> 00:09:06,990

other issues but to first order it works

224

00:09:11,660 --> 00:09:10,620

pretty well and so fine particulates so

225

00:09:14,810 --> 00:09:11,670

if we're looking at the Martian dust

226

00:09:16,490 --> 00:09:14,820

rather than Martian soils or rocks have

227

00:09:19,130 --> 00:09:16,500

a very different set of sensitivities

228

00:09:21,320 --> 00:09:19,140

and so things go very nonlinear and we

229

00:09:23,240 --> 00:09:21,330

have basically we become more sensitive

230

00:09:24,800 --> 00:09:23,250

to things like carbonates and less

231

00:09:27,110 --> 00:09:24,810

sensitive to things like period scenes

232

00:09:30,410 --> 00:09:27,120

so there's a whole there's a very large

233

00:09:33,280 --> 00:09:30,420

set of rules that goes along with it why

234

00:09:36,920 --> 00:09:33,290

is that another particular example um

235

00:09:38,450 --> 00:09:36,930

essentially when it's with coarse

236

00:09:40,160 --> 00:09:38,460

particulates you don't get photons

237

00:09:43,100 --> 00:09:40,170

basically going through individual

238

00:09:46,340 --> 00:09:43,110

grains and if you once you get below

239

00:09:47,540 --> 00:09:46,350

about 50 microns or so basically the the

240

00:09:49,820 --> 00:09:47,550

photons will start passing through

241

00:09:54,650 --> 00:09:49,830

multiple grains and so the scattering

242

00:09:55,760 --> 00:09:54,660

the you get volume scattering okay

243

00:09:57,650 --> 00:09:55,770

looking at visible and near-infrared

244

00:10:00,380 --> 00:09:57,660

spectroscopy so now we're looking at

245

00:10:03,680 --> 00:10:00,390

reflected light that's basically just

246

00:10:05,120 --> 00:10:03,690

like you see with your eyes and there is

247

00:10:06,060 --> 00:10:05,130

no set in a hard definition for

248

00:10:07,740 --> 00:10:06,070

wavelength ranges

249

00:10:09,090 --> 00:10:07,750

I'm just going to arbitrarily define it

250

00:10:11,790 --> 00:10:09,100

is about point for the 4 micron

251  
00:10:13,440 --> 00:10:11,800  
wavelength and this has a whole unique

252  
00:10:15,170 --> 00:10:13,450  
set of sensitivity that's highly

253  
00:10:18,450 --> 00:10:15,180  
complementary to the thermal infrared

254  
00:10:21,720 --> 00:10:18,460  
essentially we're sensitive to iron two

255  
00:10:24,240 --> 00:10:21,730  
plus + 3 + electronic transitions very

256  
00:10:28,500 --> 00:10:24,250  
sensitive to 0 h h<sub>2</sub>o and carbonate

257  
00:10:30,540 --> 00:10:28,510  
vibrational overtones and so and you

258  
00:10:32,340 --> 00:10:30,550  
have a high sensitivity for varia for a

259  
00:10:34,560 --> 00:10:32,350  
certain set of compositions and particle

260  
00:10:37,190 --> 00:10:34,570  
sizes and the behavior tends to be

261  
00:10:39,810 --> 00:10:37,200  
highly Nanyan nonlinear so in this case

262  
00:10:41,550 --> 00:10:39,820  
you can basically you can detect things

263  
00:10:43,830 --> 00:10:41,560

like very small percentages or

264

00:10:47,340 --> 00:10:43,840

abundances of Pylos silicates or clays

265

00:10:48,840 --> 00:10:47,350

present and you would but on the other

266

00:10:51,420 --> 00:10:48,850

hand you wouldn't detect courts or

267

00:10:52,830 --> 00:10:51,430

feldspar and basically these are some of

268

00:10:54,750 --> 00:10:52,840

the different types of minerals that you

269

00:10:57,180 --> 00:10:54,760

can detect there's a guy and these are

270

00:10:58,950 --> 00:10:57,190

the iron two-plus absorptions non

271

00:11:03,380 --> 00:10:58,960

tonight which is a phyllosilicate as

272

00:11:06,240 --> 00:11:03,390

these 1.4 1.9 2.3 micron absorptions

273

00:11:08,970 --> 00:11:06,250

hematite has the fe 3 plus iron

274

00:11:11,250 --> 00:11:08,980

three-plus absorptions gypsum has water

275

00:11:12,570 --> 00:11:11,260

absorption is calcite has the carbonate

276

00:11:15,750 --> 00:11:12,580

absorption so these all have their

277

00:11:20,400 --> 00:11:15,760

distinct signatures that are very easy

278

00:11:22,380 --> 00:11:20,410

to distinguish from one another so I'm

279

00:11:24,180 --> 00:11:22,390

going to start with basically this step

280

00:11:25,410 --> 00:11:24,190

here collecting accurate data I want to

281

00:11:26,670 --> 00:11:25,420

go over some of the different

282

00:11:30,270 --> 00:11:26,680

instruments that have been flown on the

283

00:11:31,980 --> 00:11:30,280

different spacecraft basically to give a

284

00:11:34,370 --> 00:11:31,990

sense of what kind of data is being

285

00:11:36,840 --> 00:11:34,380

collected and what is capable of doing

286

00:11:38,040 --> 00:11:36,850

and the first one will start I'm going

287

00:11:41,940 --> 00:11:38,050

to start with a thermal infrared because

288

00:11:43,740 --> 00:11:41,950

it's my bias this is the Mars Global

289

00:11:46,770 --> 00:11:43,750

Surveyor thermal emission spectrometer

290

00:11:48,930 --> 00:11:46,780

and the it's a michelson interferometer

291

00:11:50,340 --> 00:11:48,940

basically two orthogonal mirrors and a

292

00:11:51,600 --> 00:11:50,350

beam splitter you split the light you

293

00:11:52,920 --> 00:11:51,610

combine it again you get in your fair

294

00:11:55,440 --> 00:11:52,930

grams and somehow you can magically

295

00:11:59,160 --> 00:11:55,450

transform that into radians versus

296

00:12:01,800 --> 00:11:59,170

wavelength it is a spectrometer not an

297

00:12:04,740 --> 00:12:01,810

imager so this is the type of data that

298

00:12:06,900 --> 00:12:04,750

we get out of the spec the the test

299

00:12:09,600 --> 00:12:06,910

instrument from about 60 to 50 microns

300

00:12:10,950 --> 00:12:09,610

and you basically the line basically

301

00:12:12,570 --> 00:12:10,960

shows a bunch of different things if

302

00:12:14,010 --> 00:12:12,580

you're tuned to what's going on here yet

303

00:12:16,410 --> 00:12:14,020

the co2 absorption this is atmospheric

304

00:12:20,050 --> 00:12:16,420

dust minus c o-- two bands water vapor

305

00:12:23,080 --> 00:12:20,060

and this double hump right here

306

00:12:25,720 --> 00:12:23,090

is basically the hematite that was found

307

00:12:28,120 --> 00:12:25,730

in sinus meridiani so if we try to make

308

00:12:29,950 --> 00:12:28,130

out an image from the the data from the

309

00:12:32,260 --> 00:12:29,960

from the test instrument you can

310

00:12:34,630 --> 00:12:32,270

basically build up crude images with

311

00:12:36,310 --> 00:12:34,640

these strips you don't have very good

312

00:12:40,000 --> 00:12:36,320

resolution about three kilometers per

313

00:12:43,690 --> 00:12:40,010

pixel but you can you can locate on a

314

00:12:46,060 --> 00:12:43,700

map the location of these unique

315

00:12:47,890 --> 00:12:46,070

spectral features and I'm showing this

316

00:12:49,600 --> 00:12:47,900

sort of for historical purposes because

317

00:12:52,420 --> 00:12:49,610

once as a grad student I spent about a

318

00:12:56,020 --> 00:12:52,430

full week putting this image together to

319

00:12:58,540 --> 00:12:56,030

try to map out where the hematite was so

320

00:13:00,190 --> 00:12:58,550

so we see a human-type map like when

321

00:13:03,280 --> 00:13:00,200

they were deciding where that the rover

322

00:13:06,430 --> 00:13:03,290

down it's really the strengths of that

323

00:13:09,100 --> 00:13:06,440

feature is being bad um generally it's

324

00:13:10,450 --> 00:13:09,110

the strength of that feature you can do

325

00:13:12,070 --> 00:13:10,460

a little bit more of that deconvolution

326

00:13:15,190 --> 00:13:12,080

thing where you try to get the weighting

327

00:13:16,360 --> 00:13:15,200

of the of the shape in the spectrum but

328

00:13:18,790 --> 00:13:16,370

yeah essentially what you're looking at

329

00:13:20,800 --> 00:13:18,800

the strength of that feature and I'll

330

00:13:26,250 --> 00:13:20,810

show another image later on that shows a

331

00:13:28,540 --> 00:13:26,260

more detailed map the other thermally

332

00:13:30,220 --> 00:13:28,550

orbital thermal instrument we have is

333

00:13:31,750 --> 00:13:30,230

the thermal emission imaging system this

334

00:13:34,750 --> 00:13:31,760

is Themis it's on a Mars Odyssey

335

00:13:36,640 --> 00:13:34,760

spacecraft and the combination of tests

336

00:13:38,680 --> 00:13:36,650

and Themis is actually very a very nice

337

00:13:40,450 --> 00:13:38,690

combination one is a spectrometer with

338

00:13:43,240 --> 00:13:40,460

low spatial resolution but high spectral

339

00:13:45,670 --> 00:13:43,250

resolution Themis has high spatial

340

00:13:48,040 --> 00:13:45,680

resolution 100 meters per pixel so they

341

00:13:50,500 --> 00:13:48,050

can collect reasonable images of the

342

00:13:52,300 --> 00:13:50,510

surface but it has low spectral

343

00:13:54,970 --> 00:13:52,310

resolution and we're only looking at

344

00:13:58,150 --> 00:13:54,980

basically nine different wavelengths

345

00:13:59,740 --> 00:13:58,160

between about 7 15 microns so whereas we

346

00:14:01,210 --> 00:13:59,750

were building a crude pictures but nice

347

00:14:03,010 --> 00:14:01,220

spectra with tests we build up nice

348

00:14:05,290 --> 00:14:03,020

pictures but crude spectra with Themis

349

00:14:07,570 --> 00:14:05,300

and this is an example of Themis data

350

00:14:10,680 --> 00:14:07,580

this is an infrared image of a crater

351

00:14:13,360 --> 00:14:10,690

off in northern service major and the

352

00:14:16,420 --> 00:14:13,370

boxes basically represent the locations

353

00:14:18,220 --> 00:14:16,430

of the the spectra that were applauded

354

00:14:20,410 --> 00:14:18,230

over here on the right and you can see

355

00:14:24,010 --> 00:14:20,420

that basically the colors show some

356

00:14:26,290 --> 00:14:24,020

co-located different spectral surfaces

357

00:14:27,880 --> 00:14:26,300

in this case we have a surface with

358

00:14:30,220 --> 00:14:27,890

strong spectral features at Short

359

00:14:32,319 --> 00:14:30,230

wavelengths which is indicative of a

360

00:14:34,359 --> 00:14:32,329

high silica content

361

00:14:37,419 --> 00:14:34,369

the if you look at test data it shows

362

00:14:39,729 --> 00:14:37,429

that this area right here is composed of

363

00:14:41,379 --> 00:14:39,739

basically quartz and feldspar which is

364

00:14:46,869 --> 00:14:41,389

generally I mean it's basically a

365

00:14:48,220 --> 00:14:46,879

granite on the surface of Mars the third

366

00:14:50,259 --> 00:14:48,230

thermal instrument is the Mars

367

00:14:51,789 --> 00:14:50,269

exploration Rovers mini tests it's also

368

00:14:55,739 --> 00:14:51,799

a mickelson air parameter just like

369

00:14:57,699 --> 00:14:55,749

tests it's like tests but mini and

370

00:14:59,650 --> 00:14:57,709

essentially it's sitting there on the

371

00:15:02,619 --> 00:14:59,660

surface and can collect spectra in these

372

00:15:04,660 --> 00:15:02,629

dots here basically represent the the

373

00:15:07,299 --> 00:15:04,670

spot size of what we're capable of

374

00:15:09,069 --> 00:15:07,309

resolving on this image here is a little

375

00:15:11,079 --> 00:15:09,079

bit faint but you'll see that warmer

376

00:15:12,609 --> 00:15:11,089

colors like reds basically represent

377

00:15:14,139 --> 00:15:12,619

warmer surface temperatures cooler

378

00:15:16,119 --> 00:15:14,149

colors like blues represent holder

379

00:15:18,039 --> 00:15:16,129

surface temperatures and for each one of

380

00:15:20,229 --> 00:15:18,049

these thoughts were collecting a full

381

00:15:21,519 --> 00:15:20,239

spectrum with which we can use to try to

382

00:15:27,609 --> 00:15:21,529

characterize the mineralogy of the

383

00:15:29,530 --> 00:15:27,619

surface okay almost done we've got two

384

00:15:31,350 --> 00:15:29,540

more instruments Mars Express Omega

385

00:15:33,340 --> 00:15:31,360

Omega is a visible and near-infrared

386

00:15:34,929 --> 00:15:33,350

actually I think it's just an earring

387

00:15:37,329 --> 00:15:34,939

for its thick no it's a visible and

388

00:15:40,199 --> 00:15:37,339

near-infrared spectrometer whisk brooms

389

00:15:42,850 --> 00:15:40,209

grading spectrometer and this was

390

00:15:45,249 --> 00:15:42,860

probably what I guess I would consider

391

00:15:46,840 --> 00:15:45,259

sort of the first high quality visible

392

00:15:51,009 --> 00:15:46,850

near-infrared spectrometer to go to Mars

393

00:15:52,629 --> 00:15:51,019

certainly with a complete data set there

394

00:15:54,159 --> 00:15:52,639

was one on the Phobos spacecraft back in

395

00:15:56,679 --> 00:15:54,169

nineteen ninety but collected a limited

396

00:15:59,379 --> 00:15:56,689

amount of data and so we can create

397

00:16:01,689 --> 00:15:59,389

crude images with about 500 meters per

398

00:16:03,549 --> 00:16:01,699

pixel spatial sampling at periapsis ours

399

00:16:04,989 --> 00:16:03,559

expresses in actually quite elliptical

400

00:16:06,400 --> 00:16:04,999

orbit so if you're looking at Mars from

401  
00:16:09,220 --> 00:16:06,410  
farther away it's going to be a larger

402  
00:16:11,319 --> 00:16:09,230  
pixel size and you can build up pictures

403  
00:16:14,199 --> 00:16:11,329  
with the different spectra so we're

404  
00:16:16,299 --> 00:16:14,209  
taking full spectra at high spectral

405  
00:16:19,269 --> 00:16:16,309  
resolution and sort of a reasonable

406  
00:16:23,829 --> 00:16:19,279  
spatial resolution and in this case for

407  
00:16:25,119 --> 00:16:23,839  
showing essentially data that shows the

408  
00:16:28,449 --> 00:16:25,129  
difference between different iron

409  
00:16:30,280 --> 00:16:28,459  
two-plus absorptions with olivene low

410  
00:16:31,929 --> 00:16:30,290  
calcium kerosene high calcium kerosene

411  
00:16:34,600 --> 00:16:31,939  
you can see the distinct how they are

412  
00:16:37,539 --> 00:16:34,610  
spatially Colo how they're spatially

413  
00:16:40,239 --> 00:16:37,549

distributed on Martian surface for scale

414

00:16:41,889 --> 00:16:40,249

this is two degrees of latitude in a

415

00:16:43,759 --> 00:16:41,899

degree of latitude on Mars it's about 60

416

00:16:47,509 --> 00:16:43,769

kilometers so this is about 120

417

00:16:49,160 --> 00:16:47,519

there's from your tip here and this is

418

00:16:51,229 --> 00:16:49,170

from polki at all it's being cut off

419

00:16:55,429 --> 00:16:51,239

that I'm trying to reference things when

420

00:16:57,049 --> 00:16:55,439

I show other people's work and then

421

00:16:58,460 --> 00:16:57,059

finally we have the Mars Mars

422

00:16:59,929 --> 00:16:58,470

Reconnaissance Orbiter compact

423

00:17:01,549 --> 00:16:59,939

reconnaissance imaging spectrometer for

424

00:17:03,619 --> 00:17:01,559

mars basically this is the chrism

425

00:17:07,699 --> 00:17:03,629

instrument it's a push broom grading

426

00:17:10,340 --> 00:17:07,709

spectrometer and this is essentially a

427

00:17:12,500 --> 00:17:10,350

very high quality data set that gives us

428

00:17:15,590 --> 00:17:12,510

18 meters per pixel spatial sampling

429

00:17:18,439 --> 00:17:15,600

with 544 spectral channels from point 3

430

00:17:20,510 --> 00:17:18,449

to 3.9 microns so essentially this is

431

00:17:23,049 --> 00:17:20,520

what we're trying to get at with testing

432

00:17:25,309 --> 00:17:23,059

Themis but you've got in the with a

433

00:17:26,929 --> 00:17:25,319

visible near infrared is basically both

434

00:17:29,210 --> 00:17:26,939

high spectral resolution and high

435

00:17:30,440 --> 00:17:29,220

spatial resolution and it's easier to

436

00:17:32,659 --> 00:17:30,450

achieve this with when you're looking at

437

00:17:34,190 --> 00:17:32,669

shorter wavelengths because of the

438

00:17:37,490 --> 00:17:34,200

optics don't need to be quite so large

439

00:17:39,019 --> 00:17:37,500

and you can save weight so basically we

440

00:17:41,630 --> 00:17:39,029

can collect pictures highly detailed

441

00:17:44,000 --> 00:17:41,640

pictures this is about 11 kilometers

442

00:17:45,560 --> 00:17:44,010

across and what we're mapping here is

443

00:17:48,799 --> 00:17:45,570

basically the strength of this

444

00:17:49,610 --> 00:17:48,809

absorption right here actually we're

445

00:17:51,560 --> 00:17:49,620

looking at the strength of this

446

00:17:55,850 --> 00:17:51,570

absorption right here which indicates

447

00:17:57,590 --> 00:17:55,860

hydrated silica strength absorptions on

448

00:18:00,350 --> 00:17:57,600

the surface and we can map it out in

449

00:18:01,760 --> 00:18:00,360

high detail and in turn this is the same

450

00:18:03,769 --> 00:18:01,770

crater that I showed from the Themis

451

00:18:06,860 --> 00:18:03,779

image where this list the location of

452

00:18:08,210 --> 00:18:06,870

feldspar and quartz and what prism is

453

00:18:09,680 --> 00:18:08,220

seeing is not this old Spartan course

454

00:18:13,129 --> 00:18:09,690

because it's not sensitive to it but

455

00:18:14,899 --> 00:18:13,139

seeing the hydrated silica so that it

456

00:18:19,879 --> 00:18:14,909

gives a sense of the complementary

457

00:18:23,000 --> 00:18:19,889

nature of the measurements okay so we've

458

00:18:24,620 --> 00:18:23,010

got this this these different

459

00:18:26,330 --> 00:18:24,630

spectrometers we've got a whole bunch of

460

00:18:29,269 --> 00:18:26,340

data from different wave lengths and

461

00:18:31,490 --> 00:18:29,279

different resolutions and getting at the

462

00:18:32,810 --> 00:18:31,500

surface compositions of the surface and

463

00:18:34,909 --> 00:18:32,820

then interpreting those formation

464

00:18:36,710 --> 00:18:34,919  
conditions is sort of the point the

465

00:18:37,970 --> 00:18:36,720  
first point of what we're trying to do

466

00:18:41,169 --> 00:18:37,980  
or at least what I've been trying to

467

00:18:44,930 --> 00:18:41,179  
accomplish and I'm going to start with

468

00:18:48,049 --> 00:18:44,940  
essentially what John here we bring at

469

00:18:50,080 --> 00:18:48,059  
all in 2006 proposed in paper that came

470

00:18:53,330 --> 00:18:50,090  
out in science and that was titled in

471

00:18:55,310 --> 00:18:53,340  
somewhat of a grandiose manner global

472

00:18:56,310 --> 00:18:55,320  
mineralogical in aqueous Mars history

473

00:18:59,070 --> 00:18:56,320  
derived from

474

00:19:01,049 --> 00:18:59,080  
mega Mars Express data so the

475

00:19:03,450 --> 00:19:01,059  
near-infrared spectrometer on Mars

476

00:19:05,610 --> 00:19:03,460

Express has determined the surface

477

00:19:07,860 --> 00:19:05,620

composition in a manner with which we

478

00:19:10,080 --> 00:19:07,870

can basically recreate the aqueous

479

00:19:13,049 --> 00:19:10,090

history of Mars and he broke it down

480

00:19:16,110 --> 00:19:13,059

into three compositional units which

481

00:19:19,220 --> 00:19:16,120

were then interpreted to be from three

482

00:19:21,629 --> 00:19:19,230

different eras of aqueous alteration so

483

00:19:23,850 --> 00:19:21,639

and these were the three compositional

484

00:19:28,369 --> 00:19:23,860

units phyllosilicates sulfates and

485

00:19:31,259 --> 00:19:28,379

varick oxide now phyllosilicates and

486

00:19:33,720 --> 00:19:31,269

generally they form with lots of liquid

487

00:19:36,330 --> 00:19:33,730

water and they were generally found in

488

00:19:38,730 --> 00:19:36,340

older trains on Mars the what they

489

00:19:40,440 --> 00:19:38,740

called the Milwaukee and era so and this

490

00:19:42,029 --> 00:19:40,450

was interpreted as sustained aqueous

491

00:19:44,249 --> 00:19:42,039

alteration of materials during the

492

00:19:46,289 --> 00:19:44,259

Nowacki and so this is graded 3.7

493

00:19:50,009 --> 00:19:46,299

billion years ago plus or minus quite a

494

00:19:52,590 --> 00:19:50,019

few million years in terms of error and

495

00:19:56,759 --> 00:19:52,600

then the second part of this was that if

496

00:19:59,580 --> 00:19:56,769

at some point Mars changed its global

497

00:20:03,480 --> 00:19:59,590

aqueous environment from something with

498

00:20:05,749 --> 00:20:03,490

relatively moderate to high pH is and we

499

00:20:08,580 --> 00:20:05,759

had a vulcanism driven sulfur source

500

00:20:12,539 --> 00:20:08,590

volcanoes basically release lots of

501  
00:20:15,720 --> 00:20:12,549  
sulfur sulfur rich gases and that can

502  
00:20:17,490 --> 00:20:15,730  
create in a citic environment which

503  
00:20:19,499 --> 00:20:17,500  
would change a global equus chemistry

504  
00:20:22,409 --> 00:20:19,509  
this happened during the late milwaukee

505  
00:20:26,009 --> 00:20:22,419  
and throughout the experian and any

506  
00:20:27,990 --> 00:20:26,019  
water that was present would as it is it

507  
00:20:29,549 --> 00:20:28,000  
dissolve things in the rocks it had lots

508  
00:20:31,169 --> 00:20:29,559  
of sulphur dissolved in it had lots of

509  
00:20:33,450 --> 00:20:31,179  
magnesium and calcium and other things

510  
00:20:34,680 --> 00:20:33,460  
and when it evaporated away or the

511  
00:20:37,950 --> 00:20:34,690  
conditions changed it would precipitate

512  
00:20:39,869 --> 00:20:37,960  
out sulfates the third era was

513  
00:20:42,210 --> 00:20:39,879

characterized by limited availability of

514

00:20:45,749 --> 00:20:42,220

water during the Amazonian this is

515

00:20:48,180 --> 00:20:45,759

lesson 2.9 billion years old and results

516

00:20:49,680 --> 00:20:48,190

in basically a dominance of what

517

00:20:53,669 --> 00:20:49,690

beavered proposed was gas-solid

518

00:20:55,919 --> 00:20:53,679

weathering so this was the the three

519

00:20:58,680 --> 00:20:55,929

eras the three compositional units and

520

00:21:00,600 --> 00:20:58,690

some of it I actually agree with quite

521

00:21:02,490 --> 00:21:00,610

you know basically the phyllosilicates

522

00:21:04,139 --> 00:21:02,500

that's a very important discovery shows

523

00:21:05,970 --> 00:21:04,149

that there was a lot of water they do

524

00:21:09,180 --> 00:21:05,980

appear to be concentrated though not

525

00:21:09,930 --> 00:21:09,190

exclusive to the older terrains whereas

526

00:21:11,759 --> 00:21:09,940

other aspects

527

00:21:12,930 --> 00:21:11,769

this such as gas solid weathering which

528

00:21:16,110 --> 00:21:12,940

has never actually been shown to

529

00:21:18,570 --> 00:21:16,120

actually happen or the sulfates which is

530

00:21:19,769 --> 00:21:18,580

driven by this volcanism source where we

531

00:21:21,360 --> 00:21:19,779

know there's lots of volcanoes on Mars

532

00:21:23,909 --> 00:21:21,370

but we actually don't really have much

533

00:21:25,350 --> 00:21:23,919

idea about how much sulfur they actually

534

00:21:27,629 --> 00:21:25,360

released or actually when that ever

535

00:21:30,119 --> 00:21:27,639

occurred so some things are actually

536

00:21:34,110 --> 00:21:30,129

quite a bit more vague and I feel sort

537

00:21:36,090 --> 00:21:34,120

of need some closer scrutiny Josh are

538

00:21:40,049 --> 00:21:36,100

you going to talk about where these ages

539

00:21:42,090 --> 00:21:40,059

come from um I wasn't the the general

540

00:21:43,710 --> 00:21:42,100

ages come from okay so Mars was split up

541

00:21:46,039 --> 00:21:43,720

into sort of three different eras

542

00:21:48,360 --> 00:21:46,049

Milwaukee and hesperia and Amazonian and

543

00:21:51,389 --> 00:21:48,370

nuh Joaquin is sort of the heavily

544

00:21:53,940 --> 00:21:51,399

cratered old surfaces on Mars hesperian

545

00:21:55,680 --> 00:21:53,950

is associated with a hiss Perry enriched

546

00:21:59,009 --> 00:21:55,690

plains basically after the heavy

547

00:22:02,610 --> 00:21:59,019

bombardment and characterized by lots of

548

00:22:05,879 --> 00:22:02,620

volcanic then basically wrinkle ridges

549

00:22:08,249 --> 00:22:05,889

and then Amazonian is sort of post

550

00:22:10,049 --> 00:22:08,259

states that so they're related to sort

551  
00:22:11,610 --> 00:22:10,059  
of three different global morphologies

552  
00:22:13,529 --> 00:22:11,620  
on the surface so these are the

553  
00:22:15,720 --> 00:22:13,539  
correlations of composition with these

554  
00:22:18,240 --> 00:22:15,730  
morphological features of particular

555  
00:22:21,600 --> 00:22:18,250  
crater counts right where ages of

556  
00:22:23,789 --> 00:22:21,610  
business as well as could be done with

557  
00:22:25,529 --> 00:22:23,799  
the data that was available in fact what

558  
00:22:28,730 --> 00:22:25,539  
b-bring did ended up doing was creating

559  
00:22:32,159 --> 00:22:28,740  
his own Mars Martian time scale and

560  
00:22:34,110 --> 00:22:32,169  
reset the different dates so there's

561  
00:22:35,759 --> 00:22:34,120  
sort of the Bering adult time scale and

562  
00:22:37,529 --> 00:22:35,769  
then there's the traditional Mars time

563  
00:22:44,899 --> 00:22:37,539

scale but they roughly correlate with

564

00:22:48,630 --> 00:22:44,909

one another how do I do that no there's

565

00:22:55,170 --> 00:22:48,640

more life or something light and

566

00:23:05,100 --> 00:22:55,180

full note lecture straight demo demo

567

00:23:06,390 --> 00:23:05,110

demo oh nice thank you okay so going

568

00:23:08,640 --> 00:23:06,400

over those those three different

569

00:23:10,020 --> 00:23:08,650

compositions we have phyllosilicates and

570

00:23:13,050 --> 00:23:10,030

once again we're showing chrim data

571

00:23:15,210 --> 00:23:13,060

chrim has some beautiful images showing

572

00:23:16,670 --> 00:23:15,220

an extreme detail the distribution of

573

00:23:18,930 --> 00:23:16,680

phyllosilicates on the Martian surface

574

00:23:20,760 --> 00:23:18,940

once again is about 11 kilometers across

575

00:23:22,200 --> 00:23:20,770

this is an area called newly fausse

576

00:23:25,440 --> 00:23:22,210

which has also high olivene

577

00:23:28,080 --> 00:23:25,450

concentration surfaces but essentially

578

00:23:29,580 --> 00:23:28,090

the phyllosilicates Milwaukee are found

579

00:23:32,790 --> 00:23:29,590

in Milwaukee and terrains the older

580

00:23:34,470 --> 00:23:32,800

terrains and remember that the

581

00:23:37,080 --> 00:23:34,480

phyllosilicates required generally a

582

00:23:39,060 --> 00:23:37,090

moderate to high pH of water to form and

583

00:23:41,910 --> 00:23:39,070

they will not necessarily form in an

584

00:23:43,200 --> 00:23:41,920

acidic environment otherwise the

585

00:23:44,730 --> 00:23:43,210

formation environment remains actually

586

00:23:46,230 --> 00:23:44,740

quite unclear and that's one of the

587

00:23:49,020 --> 00:23:46,240

concerns for the Mars Science Laboratory

588

00:23:51,060 --> 00:23:49,030

landing sites a lot of them are proposed

589

00:23:53,310 --> 00:23:51,070

to be in phyllosilicate rich terrains

590

00:23:56,010 --> 00:23:53,320

and yet one of the problems has been

591

00:23:59,190 --> 00:23:56,020

getting the geologic context of exactly

592

00:24:00,870 --> 00:23:59,200

what was going on was this a surface or

593

00:24:03,150 --> 00:24:00,880

subsurface formation environment and

594

00:24:04,890 --> 00:24:03,160

things like that and then the

595

00:24:07,500 --> 00:24:04,900

concentrations all those it shows oh

596

00:24:10,860 --> 00:24:07,510

nice you know sort of blood-red high

597

00:24:12,960 --> 00:24:10,870

concentrations the concentrations can

598

00:24:14,730 --> 00:24:12,970

actually be quite small and in most

599

00:24:16,020 --> 00:24:14,740

cases they're probably less than ten or

600

00:24:18,810 --> 00:24:16,030

fifteen percent there's some argument

601  
00:24:21,030 --> 00:24:18,820  
over the strongest concentrations but in

602  
00:24:22,560 --> 00:24:21,040  
general they're low concentrations and

603  
00:24:23,880 --> 00:24:22,570  
one of the reasons we know they're low

604  
00:24:26,480 --> 00:24:23,890  
is because the third one's red

605  
00:24:29,820 --> 00:24:26,490  
measurements actually don't detect them

606  
00:24:31,530 --> 00:24:29,830  
and the major groups is not just ok so

607  
00:24:33,030 --> 00:24:31,540  
we've identified phyllosilicates but

608  
00:24:34,440 --> 00:24:33,040  
phyllosilicates if you're a geologist

609  
00:24:35,970 --> 00:24:34,450  
you know you can split this up into

610  
00:24:37,050 --> 00:24:35,980  
different groups that phyllosilicates in

611  
00:24:39,360 --> 00:24:37,060  
each one of those groups can be split up

612  
00:24:41,580 --> 00:24:39,370  
into even different specific types of

613  
00:24:43,530 --> 00:24:41,590

phyllosilicates they've actually

614

00:24:45,450 --> 00:24:43,540

identified elides chlorides kaolin I'd

615

00:24:47,040 --> 00:24:45,460

serpentines and smack tights I think

616

00:24:50,070 --> 00:24:47,050

it's just the dieter he drilled not this

617

00:24:51,600 --> 00:24:50,080

tri octahedral spec tights but a variety

618

00:24:53,190 --> 00:24:51,610

of different phyllosilicates have been

619

00:24:54,960 --> 00:24:53,200

found which indicate different source

620

00:24:57,660 --> 00:24:54,970

compositions or even different formation

621

00:24:59,370 --> 00:24:57,670

conditions and this gives us sort of a

622

00:25:01,529 --> 00:24:59,380

global distribution of what's been found

623

00:25:02,879 --> 00:25:01,539

so these little boxes basic

624

00:25:06,210 --> 00:25:02,889

show where they where they've identified

625

00:25:07,889 --> 00:25:06,220

them however their boxes don't represent

626

00:25:09,599 --> 00:25:07,899

the actual aerial coverage the actual

627

00:25:12,950 --> 00:25:09,609

area coverage on the surface is much

628

00:25:15,690 --> 00:25:12,960

much much less than 1% the colors uh

629

00:25:17,099 --> 00:25:15,700

they I don't know precisely there that

630

00:25:19,889 --> 00:25:17,109

essentially they're describing the

631

00:25:22,739 --> 00:25:19,899

different types here although I don't

632

00:25:24,899 --> 00:25:22,749

really I'm sorry its topography altitude

633

00:25:27,119 --> 00:25:24,909

oh the color of the yes this is a

634

00:25:28,649 --> 00:25:27,129

topographic map in the background okay

635

00:25:33,060 --> 00:25:28,659

sorry I met you I thought you meant the

636

00:25:35,669 --> 00:25:33,070

colors of the boxes so yeah the

637

00:25:39,320 --> 00:25:35,679

volcanoes olympus mons starts its

638

00:25:42,719 --> 00:25:39,330

volcanoes and such and alex Ryanair's

639

00:25:45,269 --> 00:25:42,729

second composition sulfates this is a

640

00:25:48,119 --> 00:25:45,279

picture from the pan cam on in meridiani

641

00:25:50,430 --> 00:25:48,129

i think this is victoria crater showing

642

00:25:52,680 --> 00:25:50,440

the outcrops rocks that i'm sure you've

643

00:25:56,129 --> 00:25:52,690

all seen pictures of beautifully cross

644

00:25:58,529 --> 00:25:56,139

fitted essentially sandstones and these

645

00:26:02,849 --> 00:25:58,539

are chock-full of sulfates as well as

646

00:26:05,789 --> 00:26:02,859

Pyrrhic scenes in silica and and belts

647

00:26:07,080 --> 00:26:05,799

bars but essentially we see lots and

648

00:26:11,279 --> 00:26:07,090

lots of sulfates in places like

649

00:26:13,200 --> 00:26:11,289

meridiani and there's many occurrences

650

00:26:15,479 --> 00:26:13,210

within equatorial layered deposits

651  
00:26:17,399 --> 00:26:15,489  
throughout sort of the Valles Marineris

652  
00:26:20,460 --> 00:26:17,409  
region to Mars throughout grade yani

653  
00:26:23,039 --> 00:26:20,470  
region essentially there's sort of they

654  
00:26:26,009 --> 00:26:23,049  
occur widespread even if they're sort of

655  
00:26:28,019 --> 00:26:26,019  
isolated throughout equatorial mars with

656  
00:26:29,999 --> 00:26:28,029  
one exception of this really strong

657  
00:26:32,399 --> 00:26:30,009  
deposit that they found right next to

658  
00:26:34,349 --> 00:26:32,409  
the north polar cap so you don't see

659  
00:26:36,419 --> 00:26:34,359  
sulfates anywhere outside of equatorial

660  
00:26:39,659 --> 00:26:36,429  
Mars except for right next to the polar

661  
00:26:42,180 --> 00:26:39,669  
cap and what is doing there and why it's

662  
00:26:44,729 --> 00:26:42,190  
there it's sort of anybody's guess at

663  
00:26:46,560 --> 00:26:44,739

this point so the competitions include

664

00:26:49,229 --> 00:26:46,570

various hydration states of calcium and

665

00:26:51,359 --> 00:26:49,239

magnesium sulfate indicating different

666

00:26:52,830 --> 00:26:51,369

cations and basically the hydration

667

00:26:54,389 --> 00:26:52,840

state is very sensitive to the

668

00:26:55,889 --> 00:26:54,399

temperature environment so you can

669

00:26:58,349 --> 00:26:55,899

basically get out what the history of

670

00:27:01,349 --> 00:26:58,359

this of the sulfates have been in recent

671

00:27:02,519 --> 00:27:01,359

climate history and of course as I show

672

00:27:04,859 --> 00:27:02,529

they're found by rovers in both

673

00:27:06,389 --> 00:27:04,869

meridians and ingu said and what's

674

00:27:08,129 --> 00:27:06,399

really interesting is despite the

675

00:27:10,589 --> 00:27:08,139

widespread high concentrations of

676

00:27:12,539 --> 00:27:10,599

sulfates that you see in meridiani we're

677

00:27:14,790 --> 00:27:12,549

talking thirty or forty percent in some

678

00:27:16,860 --> 00:27:14,800

cases they're not detected for more

679

00:27:18,360 --> 00:27:16,870

it we're confident that they're there

680

00:27:19,770 --> 00:27:18,370

and yet you can't see them from the

681

00:27:23,430 --> 00:27:19,780

spectrometers from orbit even though it

682

00:27:25,140 --> 00:27:23,440

can be resolved so that's one note of

683

00:27:27,330 --> 00:27:25,150

caution about when you look at the

684

00:27:29,490 --> 00:27:27,340

orbital data when you're not seeing

685

00:27:32,310 --> 00:27:29,500

something it's not necessarily telling

686

00:27:34,140 --> 00:27:32,320

you much and in the case of Meridian

687

00:27:36,180 --> 00:27:34,150

Gusev it's the only detection of jura

688

00:27:38,550 --> 00:27:36,190

site which is an iron sulfate which

689

00:27:40,290 --> 00:27:38,560

indicates acidic conditions so when you

690

00:27:41,880 --> 00:27:40,300

see sulfates you don't necessarily think

691

00:27:45,060 --> 00:27:41,890

okay this had to be an acidic

692

00:27:47,040 --> 00:27:45,070

environment you can form calcium

693

00:27:49,350 --> 00:27:47,050

magnesium sulfate sand slightly in

694

00:27:50,970 --> 00:27:49,360

relatively normal environments but when

695

00:27:52,380 --> 00:27:50,980

you have things like iron sulfate is

696

00:27:54,360 --> 00:27:52,390

when you can start to say something

697

00:27:56,910 --> 00:27:54,370

about the actual aqueous conditions in

698

00:28:00,900 --> 00:27:56,920

terms of the pH what's the best guess as

699

00:28:03,690 --> 00:28:00,910

to why you don't see any more I'm I'm at

700

00:28:05,070 --> 00:28:03,700

a complete loss actually I I really

701  
00:28:07,560 --> 00:28:05,080  
don't know I mean you can always argue

702  
00:28:08,820 --> 00:28:07,570  
textures or particle sizes or you know

703  
00:28:11,340 --> 00:28:08,830  
interference from other different

704  
00:28:15,930 --> 00:28:11,350  
compositions but it's that's all hand

705  
00:28:20,010 --> 00:28:15,940  
waving and then finally the the third

706  
00:28:24,090 --> 00:28:20,020  
type is ferric oxide and as simple as

707  
00:28:26,040 --> 00:28:24,100  
you can put is Mars is red there's we

708  
00:28:27,630 --> 00:28:26,050  
that's been known for a long time you

709  
00:28:29,580 --> 00:28:27,640  
see that red that red color of the

710  
00:28:32,370 --> 00:28:29,590  
surface it looks like rust Mars is sort

711  
00:28:33,660 --> 00:28:32,380  
of in a way Rusted but one of the

712  
00:28:35,190 --> 00:28:33,670  
interesting things is that the actual

713  
00:28:36,930 --> 00:28:35,200

weathering process actually remains a

714

00:28:39,450 --> 00:28:36,940

little bit unclear you have these

715

00:28:41,490 --> 00:28:39,460

ubiquitous nanophase iron oxide it

716

00:28:44,670 --> 00:28:41,500

generally implies very limited amount of

717

00:28:46,200 --> 00:28:44,680

liquid wealth of liquid water and one of

718

00:28:47,970 --> 00:28:46,210

the questions is how much water is

719

00:28:49,590 --> 00:28:47,980

necessary can you get ads orbbed layers

720

00:28:51,750 --> 00:28:49,600

that actually make this process occurred

721

00:28:53,280 --> 00:28:51,760

you have to have like actual amounts of

722

00:28:56,160 --> 00:28:53,290

liquid water or can this be in a bone

723

00:28:59,940 --> 00:28:56,170

dry environment and it's actually still

724

00:29:01,710 --> 00:28:59,950

not really well known so there's our

725

00:29:03,960 --> 00:29:01,720

three compositions that have been

726

00:29:06,780 --> 00:29:03,970

proposed as sort of describing the

727

00:29:09,390 --> 00:29:06,790

global aqueous and a compositional

728

00:29:10,860 --> 00:29:09,400

Anchorage history but essentially i'm

729

00:29:13,110 --> 00:29:10,870

going to go over some other things that

730

00:29:15,120 --> 00:29:13,120

you can add to this and i would argue

731

00:29:20,160 --> 00:29:15,130

that there's a lot to add to this this

732

00:29:23,130 --> 00:29:20,170

history so the first one hematite which

733

00:29:24,630 --> 00:29:23,140

i mentioned before and this is this is

734

00:29:25,360 --> 00:29:24,640

as well as you can do with the test data

735

00:29:28,650 --> 00:29:25,370

into

736

00:29:31,500 --> 00:29:28,660

the mapping the detailed distribution

737

00:29:33,700 --> 00:29:31,510

key mikhay is a relatively unique

738

00:29:35,290 --> 00:29:33,710

composition those blueberries that you

739

00:29:37,840 --> 00:29:35,300

see at the meridiani site that's the

740

00:29:39,130 --> 00:29:37,850

source of the hematite and the current

741

00:29:41,740 --> 00:29:39,140

is in a bunch of different areas

742

00:29:43,150 --> 00:29:41,750

meridiani air Moorea man que haces Oh

743

00:29:45,430 --> 00:29:43,160

Pierre and Kendrick as much as well as

744

00:29:46,840 --> 00:29:45,440

he beats casma they all have identical

745

00:29:48,640 --> 00:29:46,850

spectral signatures and they're all

746

00:29:50,770 --> 00:29:48,650

associated with a more extensive sulfate

747

00:29:52,870 --> 00:29:50,780

rich deposits so these are layered

748

00:29:55,600 --> 00:29:52,880

terrains and the hematite seems to be

749

00:29:58,630 --> 00:29:55,610

associated with a relatively thin layer

750

00:30:01,740 --> 00:29:58,640

of maybe 50 or 100 meters within a much

751

00:30:03,940 --> 00:30:01,750

more extensive stack of deposit and so

752

00:30:06,040 --> 00:30:03,950

I'm not sure anybody really knows what

753

00:30:07,690 --> 00:30:06,050

means but in terms of what it seems to

754

00:30:09,820 --> 00:30:07,700

be saying to me is that this might be

755

00:30:11,680 --> 00:30:09,830

indicating periodic episodes of a unique

756

00:30:14,169 --> 00:30:11,690

aqueous chemistry throughout much much

757

00:30:17,919 --> 00:30:14,179

Martian history because these different

758

00:30:20,110 --> 00:30:17,929

areas seem to span quite an age quite a

759

00:30:25,960 --> 00:30:20,120

range of ages from late Milwaukee into

760

00:30:27,669 --> 00:30:25,970

early Amazonian silica there was a

761

00:30:30,820 --> 00:30:27,679

article that just came out in geology

762

00:30:33,280 --> 00:30:30,830

this month on the discovery of hydrated

763

00:30:35,799 --> 00:30:33,290

silica on Mars which we've discovered a

764

00:30:38,140 --> 00:30:35,809

number of times over at this point we

765

00:30:40,270 --> 00:30:38,150

have silica phases in a variety of forms

766

00:30:43,030 --> 00:30:40,280

from courts to hydrated or dehydrated

767

00:30:46,330 --> 00:30:43,040

amorphous silica in terms of coatings

768

00:30:48,070 --> 00:30:46,340

are actually bulk compositions and they

769

00:30:49,870 --> 00:30:48,080

seem to be forming in a variety of

770

00:30:51,970 --> 00:30:49,880

different geological situations in

771

00:30:54,400 --> 00:30:51,980

different locations home plate at Gusev

772

00:30:56,380 --> 00:30:54,410

crater western Hellas Basin Radeon e

773

00:30:58,299 --> 00:30:56,390

northern lowland sirs major nidal Cirrus

774

00:31:02,290 --> 00:30:58,309

men's a Valles Marineris and the list

775

00:31:04,990 --> 00:31:02,300

will probably continue to grow and they

776

00:31:06,730 --> 00:31:05,000

seem to fall into several two categories

777

00:31:09,250 --> 00:31:06,740

if I wanted to categorize them when one

778

00:31:11,980 --> 00:31:09,260

is in terms of coatings essentially

779

00:31:13,870 --> 00:31:11,990

silica coatings tend to form and it's

780

00:31:15,430 --> 00:31:13,880

very common on desert surfaces to get

781

00:31:17,680 --> 00:31:15,440

basically a coating of more or less

782

00:31:20,200 --> 00:31:17,690

Amorphous silica on any sort of Brock

783

00:31:22,030 --> 00:31:20,210

like a basalt or whatever and then in

784

00:31:25,000 --> 00:31:22,040

other area in other situations you'll

785

00:31:26,860 --> 00:31:25,010

see high concentrations this is silica

786

00:31:28,540 --> 00:31:26,870

in the Columbia Hills this is basically

787

00:31:32,070 --> 00:31:28,550

the rover dug up some stuff that was

788

00:31:34,960 --> 00:31:32,080

buried ninety percent by weight sio 2

789

00:31:36,649 --> 00:31:34,970

which pretty much indicates that you

790

00:31:39,349 --> 00:31:36,659

have much more extensive aqueous

791

00:31:40,700 --> 00:31:39,359

tivity you have these yellow deposits

792

00:31:42,769 --> 00:31:40,710

here this is in western Hellas Basin

793

00:31:46,460 --> 00:31:42,779

where as best as we can tell us about

794

00:31:48,080 --> 00:31:46,470

75% high silica phases which indicates a

795

00:31:51,830 --> 00:31:48,090

surface that's probably on the order of

796

00:31:55,310 --> 00:31:51,840

80 to 85 to 90 percent silica content

797

00:31:57,499 --> 00:31:55,320

and so these deposits indicate that it's

798

00:32:00,229 --> 00:31:57,509

not just a coating it's probably a much

799

00:32:02,060 --> 00:32:00,239

much more extensive aqueous activity in

800

00:32:06,710 --> 00:32:02,070

some cases this is the best guess is a

801  
00:32:09,859 --> 00:32:06,720  
hydrothermal deposit at Gusev another

802  
00:32:12,339 --> 00:32:09,869  
composition zeolites as well as I can

803  
00:32:17,320 --> 00:32:12,349  
describe it hydrated techno silicates

804  
00:32:20,749 --> 00:32:17,330  
essentially basically you you take a

805  
00:32:22,669 --> 00:32:20,759  
framework silicate and add water to the

806  
00:32:24,739 --> 00:32:22,679  
structure and that's what zeolites tend

807  
00:32:26,659 --> 00:32:24,749  
to be there usually found in altered

808  
00:32:28,659 --> 00:32:26,669  
volcanics and they usually form from

809  
00:32:30,889 --> 00:32:28,669  
interaction with alkaline groundwater

810  
00:32:33,469 --> 00:32:30,899  
and there's a whole slew of different

811  
00:32:35,029 --> 00:32:33,479  
zeolite compositions and what's

812  
00:32:37,489 --> 00:32:35,039  
interesting is that even though it's

813  
00:32:38,830 --> 00:32:37,499

it's own class of mineral type and it's

814

00:32:41,029 --> 00:32:38,840

been seen in a number of locations

815

00:32:43,580 --> 00:32:41,039

nobody's really done a whole lot on it

816

00:32:45,049 --> 00:32:43,590

yet there's a little bit that's been

817

00:32:46,999 --> 00:32:45,059

mentioned decides the presence and

818

00:32:48,080 --> 00:32:47,009

you'll read these papers it's like okay

819

00:32:49,969 --> 00:32:48,090

here's the zeolites in the

820

00:32:51,229 --> 00:32:49,979

phyllosilicates or whatever and they

821

00:32:53,119 --> 00:32:51,239

don't tend to dwell on the zeolites

822

00:32:55,820 --> 00:32:53,129

maybe because we don't know what to say

823

00:32:56,989 --> 00:32:55,830

about it yet once again this is that

824

00:33:00,499 --> 00:32:56,999

crater with the quartz and feldspar

825

00:33:02,450 --> 00:33:00,509

surface but hydrated silica and up on

826

00:33:04,399 --> 00:33:02,460

the central peak you can see basically

827

00:33:07,279 --> 00:33:04,409

high concentrations of those zeolites

828

00:33:14,269 --> 00:33:07,289

that are present so yet another

829

00:33:16,849 --> 00:33:14,279

compositional type carbonates so we're

830

00:33:20,080 --> 00:33:16,859

going through the list and I'm going to

831

00:33:24,979 --> 00:33:20,090

get tired of talking at some point I

832

00:33:26,960 --> 00:33:24,989

this is in the in the moderate to high

833

00:33:28,909 --> 00:33:26,970

albedo regions of Mars there's a

834

00:33:30,879 --> 00:33:28,919

spectral feature in the test data and

835

00:33:33,349 --> 00:33:30,889

it's this spectral feature right here

836

00:33:35,269 --> 00:33:33,359

essentially carbonates have a strong

837

00:33:37,909 --> 00:33:35,279

absorption at seven microns and in the

838

00:33:39,259 --> 00:33:37,919

fine grain particulates it's actually

839

00:33:41,629 --> 00:33:39,269

sort of like throwing a little bit of

840

00:33:43,570 --> 00:33:41,639

black carbon snow you can make a very

841

00:33:47,210 --> 00:33:43,580

big effect with a very little amount of

842

00:33:49,099 --> 00:33:47,220

the substance and you have the solar

843

00:33:50,159 --> 00:33:49,109

shoulder here which is very diagnostic

844

00:33:52,950 --> 00:33:50,169

of the present

845

00:33:55,259 --> 00:33:52,960

so carbonates mixed in with silicates or

846

00:33:56,489 --> 00:33:55,269

oxide or other materials and the dust

847

00:34:00,509 --> 00:33:56,499

factor indicate about two to five

848

00:34:02,489 --> 00:34:00,519

percent carbonate bye-bye wait and this

849

00:34:04,440 --> 00:34:02,499

distribution is ubiquitous so basically

850

00:34:05,879 --> 00:34:04,450

throughout all of Mars on them all

851  
00:34:07,200 --> 00:34:05,889  
moderate to high albedo regions but

852  
00:34:08,970 --> 00:34:07,210  
you're sensitive to this type of thing

853  
00:34:11,760 --> 00:34:08,980  
we see a little bit of carbonates and

854  
00:34:13,379 --> 00:34:11,770  
what's really interesting is that the

855  
00:34:15,629 --> 00:34:13,389  
Phoenix lander is one of these areas

856  
00:34:16,950 --> 00:34:15,639  
that shows this type of signature and

857  
00:34:19,470 --> 00:34:16,960  
what's been coming out in the last

858  
00:34:21,480 --> 00:34:19,480  
couple weeks is that they're seeing what

859  
00:34:23,039 --> 00:34:21,490  
do you know a couple of weight percent

860  
00:34:24,510 --> 00:34:23,049  
of carbonates if I remember right there

861  
00:34:27,510 --> 00:34:24,520  
actually sands are like five to ten

862  
00:34:29,159 --> 00:34:27,520  
percent but it's showing similar results

863  
00:34:31,760 --> 00:34:29,169

which I'm very happy to hear because

864

00:34:34,740 --> 00:34:31,770

it's it seems to be a pretty consistent

865

00:34:36,750 --> 00:34:34,750

so one thing about the carbonates the

866

00:34:38,909 --> 00:34:36,760

presence of carbonates and I was arguing

867

00:34:41,309 --> 00:34:38,919

with Conway last week about this but I'd

868

00:34:43,349 --> 00:34:41,319

like to push the whole atmosphere buffer

869

00:34:44,909 --> 00:34:43,359

mechanism essentially if you have a

870

00:34:47,339 --> 00:34:44,919

carbon dioxide atmosphere and you have

871

00:34:49,020 --> 00:34:47,349

other unweathered materials what you're

872

00:34:50,460 --> 00:34:49,030

going to do is draw down the CO<sub>2</sub> from

873

00:34:52,079 --> 00:34:50,470

the atmosphere when you whether those

874

00:34:54,780 --> 00:34:52,089

materials to form the carbonates and

875

00:34:56,669 --> 00:34:54,790

that mechanism will proceed until liquid

876

00:34:57,930 --> 00:34:56,679

water is no longer stable and then that

877

00:35:00,930 --> 00:34:57,940

will shut off or slowed down

878

00:35:03,270 --> 00:35:00,940

considerably so it's a nice it sounds

879

00:35:05,069 --> 00:35:03,280

nice at least it's a nice I I like that

880

00:35:06,930 --> 00:35:05,079

hypothesis is put forward by Ralph com

881

00:35:08,690 --> 00:35:06,940

way back in nineteen eighty-five to sort

882

00:35:11,280 --> 00:35:08,700

of explain why the Martian atmosphere is

883

00:35:22,230 --> 00:35:11,290

close to the triple point of water as it

884

00:35:23,970 --> 00:35:22,240

is right now see ya yeah okay widespread

885

00:35:27,120 --> 00:35:23,980

dissolution of olivene this is sort of

886

00:35:29,190 --> 00:35:27,130

almost a negative result of one thing

887

00:35:31,410 --> 00:35:29,200

that we're seeing across the planet in a

888

00:35:34,440 --> 00:35:31,420

lot of different locations and it's best

889

00:35:36,599 --> 00:35:34,450

it's best shown at Gusev crater this is

890

00:35:38,940 --> 00:35:36,609

the rock called Adirondack the

891

00:35:41,670 --> 00:35:38,950

Adirondack on the interior has a high

892

00:35:43,200 --> 00:35:41,680

olivene content the exterior has a

893

00:35:46,260 --> 00:35:43,210

weathering ryan with a low alving

894

00:35:49,349 --> 00:35:46,270

content and all the rocks in this region

895

00:35:51,120 --> 00:35:49,359

all have the same composition they're

896

00:35:53,760 --> 00:35:51,130

all Adirondack class rocks throughout

897

00:35:55,589 --> 00:35:53,770

the South Plains not in the Columbia

898

00:35:59,130 --> 00:35:55,599

Hills but throughout the plains now the

899

00:36:01,200 --> 00:35:59,140

soils basically have very low olivene

900

00:36:02,560 --> 00:36:01,210

contents and so there's a progression of

901  
00:36:05,320 --> 00:36:02,570  
high olivene content

902  
00:36:08,170 --> 00:36:05,330  
tulo olivene content and this is

903  
00:36:10,180 --> 00:36:08,180  
indicating that well all of you is going

904  
00:36:11,860 --> 00:36:10,190  
away as you're prettier basically

905  
00:36:14,590 --> 00:36:11,870  
mechanically processing this stuff from

906  
00:36:16,690 --> 00:36:14,600  
rocks into soils and we see the same

907  
00:36:18,420 --> 00:36:16,700  
pattern over and over again the cross

908  
00:36:21,760 --> 00:36:18,430  
Mars where you have high inertia

909  
00:36:25,150 --> 00:36:21,770  
basically rocky surfaces that have high

910  
00:36:26,890 --> 00:36:25,160  
lavage contents in the surrounding the

911  
00:36:30,250 --> 00:36:26,900  
surrounding soils have low olivene

912  
00:36:32,280 --> 00:36:30,260  
contents and this is this is consistent

913  
00:36:35,800 --> 00:36:32,290

with basically limited amounts of water

914

00:36:39,430 --> 00:36:35,810

dissolving away the the olivine

915

00:36:42,730 --> 00:36:39,440

informing iron oxide silica and sulfates

916

00:36:43,870 --> 00:36:42,740

and what's interesting about this is

917

00:36:46,660 --> 00:36:43,880

this actually might be a widespread

918

00:36:48,190 --> 00:36:46,670

process and it's sort of a global

919

00:36:52,440 --> 00:36:48,200

process and yet it's not really

920

00:36:55,570 --> 00:36:52,450

recognized as as a as a process which it

921

00:36:57,070 --> 00:36:55,580

it's not recognized that that water has

922

00:36:58,720 --> 00:36:57,080

played much of a role across much of

923

00:37:00,880 --> 00:36:58,730

Mars surface we're usually focused on

924

00:37:02,470 --> 00:37:00,890

these isolated phyllosilicates or

925

00:37:05,050 --> 00:37:02,480

sulfates sites and yet this might be

926

00:37:10,240 --> 00:37:05,060

actually much much more common than what

927

00:37:12,070 --> 00:37:10,250

we realized chlorine distributions and

928

00:37:14,410 --> 00:37:12,080

this is okay so getting away from

929

00:37:16,300 --> 00:37:14,420

spectroscopy a little from the visible

930

00:37:18,190 --> 00:37:16,310

to thermal infrared spectroscopy in

931

00:37:19,960 --> 00:37:18,200

going and looking at the gamma ray

932

00:37:20,860 --> 00:37:19,970

spectrometer this is an orbital

933

00:37:23,320 --> 00:37:20,870

instrument on the Mars Odyssey

934

00:37:25,330 --> 00:37:23,330

spacecraft and it gets elemental

935

00:37:27,880 --> 00:37:25,340

composition sort of six hundred

936

00:37:30,010 --> 00:37:27,890

kilometer resolution it's better at some

937

00:37:32,920 --> 00:37:30,020

elements and others one of the elements

938

00:37:35,340 --> 00:37:32,930

it does very very well with high signal

939

00:37:38,020 --> 00:37:35,350

annoys and resolution is chlorine and

940

00:37:40,270 --> 00:37:38,030

there are some strange chlorine

941

00:37:46,540 --> 00:37:40,280

anomalies basically strong chlorine

942

00:37:48,700 --> 00:37:46,550

chlorine surfaces with high a couple

943

00:37:51,000 --> 00:37:48,710

percent basically a couple percent above

944

00:37:53,380 --> 00:37:51,010

the background chlorine abundances

945

00:37:57,640 --> 00:37:53,390

covering relatively large areas of the

946

00:37:59,350 --> 00:37:57,650

planet and so the highest concentrations

947

00:38:02,440 --> 00:37:59,360

happen to be coincident with the Medusa

948

00:38:04,240 --> 00:38:02,450

phase formation which is basis you can

949

00:38:06,610 --> 00:38:04,250

actually see it topographically on the

950

00:38:08,460 --> 00:38:06,620

map some of these mounds here are parts

951  
00:38:12,100 --> 00:38:08,470  
of the Medusa phosphate formation and

952  
00:38:15,010 --> 00:38:12,110  
that these are coincident with this

953  
00:38:15,830 --> 00:38:15,020  
formation that generally gives us the

954  
00:38:18,530 --> 00:38:15,840  
impression of being

955  
00:38:20,900 --> 00:38:18,540  
in a vast ash deposit volcanic ash and

956  
00:38:22,760 --> 00:38:20,910  
so the question is is this a product of

957  
00:38:25,640 --> 00:38:22,770  
a unique alteration or is it a unique

958  
00:38:28,010 --> 00:38:25,650  
source composition and we don't know one

959  
00:38:30,560 --> 00:38:28,020  
or the other but clearly the high

960  
00:38:32,450 --> 00:38:30,570  
chlorine contents is suggestive of some

961  
00:38:35,420 --> 00:38:32,460  
kind of aqueous process that could be

962  
00:38:39,200 --> 00:38:35,430  
occurring regionally on Mars that were

963  
00:38:40,580 --> 00:38:39,210

not really detecting otherwise this is

964

00:38:44,120 --> 00:38:40,590

Ron we could you just talk about

965

00:38:47,030 --> 00:38:44,130

chlorine geologically I think salt yeah

966

00:38:50,060 --> 00:38:47,040

and that's why that's generally what you

967

00:38:55,430 --> 00:38:50,070

would think is a assaults like hey light

968

00:38:59,300 --> 00:38:55,440

table salt or whatever evaporates it is

969

00:39:01,730 --> 00:38:59,310

coming um not common because it's so

970

00:39:03,260 --> 00:39:01,740

soluble it's it'll dissolve away really

971

00:39:05,480 --> 00:39:03,270

quickly and then the only way that you

972

00:39:07,550 --> 00:39:05,490

get much out of it is when you evaporate

973

00:39:10,760 --> 00:39:07,560

the water away and you get you'll get

974

00:39:16,310 --> 00:39:10,770

the salt deposits Charlotte will correct

975

00:39:17,990 --> 00:39:16,320

me later on probably but another thing

976  
00:39:19,220 --> 00:39:18,000  
out of the gamma ray spectrometer suite

977  
00:39:21,680 --> 00:39:19,230  
of instruments this is actually from the

978  
00:39:23,870 --> 00:39:21,690  
neutron spectrometer equatorial regions

979  
00:39:26,240 --> 00:39:23,880  
are showing areas that are equivalent to

980  
00:39:27,620 --> 00:39:26,250  
I can't remember the number of sort of

981  
00:39:32,720 --> 00:39:27,630  
fifteen to twenty percent by weight

982  
00:39:34,640 --> 00:39:32,730  
water that might up to so basically in

983  
00:39:38,750 --> 00:39:34,650  
equatorial regions we're getting high

984  
00:39:40,220 --> 00:39:38,760  
hydrogen signals and from the

985  
00:39:41,780 --> 00:39:40,230  
measurements there indicating that

986  
00:39:44,030 --> 00:39:41,790  
they're probably buried a couple of

987  
00:39:46,970 --> 00:39:44,040  
centimeters and what's interesting about

988  
00:39:49,340 --> 00:39:46,980

this is in equatorial Mars water ice is

989

00:39:50,750 --> 00:39:49,350

not at all stable it's not going to

990

00:39:52,690 --> 00:39:50,760

stick around for a long wait a long

991

00:39:55,850 --> 00:39:52,700

while you can probably constructs its

992

00:39:57,590 --> 00:39:55,860

situations where you can actually seal

993

00:40:00,470 --> 00:39:57,600

it off and keep it from evaporating out

994

00:40:02,690 --> 00:40:00,480

to the atmosphere but under I think most

995

00:40:04,850 --> 00:40:02,700

people generally agree that essentially

996

00:40:06,650 --> 00:40:04,860

this is consistent with hydrated

997

00:40:09,350 --> 00:40:06,660

mineralogy so if you had a hydrated

998

00:40:11,870 --> 00:40:09,360

magnesium sulfate for example or even

999

00:40:13,580 --> 00:40:11,880

zeolites or phyllosilicates the most

1000

00:40:16,760 --> 00:40:13,590

consistent is very hydrated magnesium

1001  
00:40:19,160 --> 00:40:16,770  
sulfate so you have this vast area of

1002  
00:40:22,880 --> 00:40:19,170  
Mars this is you know thousands of

1003  
00:40:24,680 --> 00:40:22,890  
kilometers in diameter here and it's by

1004  
00:40:26,390 --> 00:40:24,690  
far the most extensive deposit of

1005  
00:40:28,340 --> 00:40:26,400  
hydrated minerals if you do buy that

1006  
00:40:28,910 --> 00:40:28,350  
argument and what's really interesting

1007  
00:40:30,500 --> 00:40:28,920  
about

1008  
00:40:33,770 --> 00:40:30,510  
this is we're not detecting any of it

1009  
00:40:35,270 --> 00:40:33,780  
from orbit with with the with the

1010  
00:40:38,560 --> 00:40:35,280  
reflectance or thermal infrared

1011  
00:40:40,280 --> 00:40:38,570  
spectrometers so we see this huge water

1012  
00:40:41,840 --> 00:40:40,290  
deposit that we're associating with

1013  
00:40:44,060 --> 00:40:41,850

hydrated mineralogy is that we're not

1014

00:40:46,160 --> 00:40:44,070

detecting by beep via any other needs

1015

00:40:47,870 --> 00:40:46,170

and one of the things that makes you

1016

00:40:49,700 --> 00:40:47,880

thurs think about this being more

1017

00:40:53,300 --> 00:40:49,710

extensive is this is often the Columbia

1018

00:40:55,070 --> 00:40:53,310

Hills and as you drag that Rover one of

1019

00:40:57,110 --> 00:40:55,080

the wheels isn't working very well and

1020

00:41:01,640 --> 00:40:57,120

it basically kicks up and stirs up all

1021

00:41:04,550 --> 00:41:01,650

the the soil and things the before this

1022

00:41:07,580 --> 00:41:04,560

was chewed up it looked like the rest of

1023

00:41:09,560 --> 00:41:07,590

the surface here and after they drove by

1024

00:41:11,090 --> 00:41:09,570

it there's all this bright material and

1025

00:41:14,000 --> 00:41:11,100

as bright material is extremely

1026

00:41:15,290 --> 00:41:14,010

sulfur-rich it's basically sulfates that

1027

00:41:18,140 --> 00:41:15,300

were just buried right underneath the

1028

00:41:19,610 --> 00:41:18,150

surface and not at all seen before they

1029

00:41:22,700 --> 00:41:19,620

kicked up that and stirred up the

1030

00:41:24,830 --> 00:41:22,710

surface and so it looks like you can

1031

00:41:26,900 --> 00:41:24,840

bury things on ours just a few

1032

00:41:28,280 --> 00:41:26,910

centimeters and very extensively and

1033

00:41:32,570 --> 00:41:28,290

we're not really quite sure what that

1034

00:41:34,940 --> 00:41:32,580

process would be okay a couple more

1035

00:41:36,200 --> 00:41:34,950

things Columbia Hills so in general I

1036

00:41:38,930 --> 00:41:36,210

just wanted to talk about the Columbia

1037

00:41:42,290 --> 00:41:38,940

Hill to Gusev crater and this is from

1038

00:41:44,960 --> 00:41:42,300

Ming at all and this is the Douglas Ming

1039

00:41:47,480 --> 00:41:44,970

and this is Dick Morris at all from 2006

1040

00:41:49,280 --> 00:41:47,490

this is dick Morris's classification

1041

00:41:50,990 --> 00:41:49,290

scheme for Gusev crater rocks so we're

1042

00:41:54,530 --> 00:41:51,000

looking at just a couple hundred meters

1043

00:41:56,930 --> 00:41:54,540

of a traverse on the Columbia Hills and

1044

00:41:58,640 --> 00:41:56,940

all of a sudden we have a derp on that

1045

00:42:01,150 --> 00:41:58,650

class piece class back state class

1046

00:42:05,090 --> 00:42:01,160

Clovis wish stone and so on and so forth

1047

00:42:06,770 --> 00:42:05,100

with all of these different basically

1048

00:42:08,810 --> 00:42:06,780

elemental compositions that indicate

1049

00:42:11,000 --> 00:42:08,820

from minor alteration to highly altered

1050

00:42:13,100 --> 00:42:11,010

basically we have this huge variety of

1051

00:42:15,290 --> 00:42:13,110

different rock types indicating

1052

00:42:17,960 --> 00:42:15,300

different types of alteration all within

1053

00:42:19,820 --> 00:42:17,970

this tiny little area within a little

1054

00:42:21,860 --> 00:42:19,830

spot on Mars that we don't detect it all

1055

00:42:23,720 --> 00:42:21,870

from orbit so this is almost as if you

1056

00:42:25,670 --> 00:42:23,730

took the entire complexity of Mars as we

1057

00:42:28,900 --> 00:42:25,680

know it right now put in a blender and

1058

00:42:31,430 --> 00:42:28,910

deposited in the Columbia Hills and

1059

00:42:33,350 --> 00:42:31,440

what's basically what this is is

1060

00:42:35,750 --> 00:42:33,360

basically just sort of a humbling thing

1061

00:42:37,610 --> 00:42:35,760

saying that okay there's all the stuff

1062

00:42:39,320 --> 00:42:37,620

that we're not detecting and this is

1063

00:42:42,069 --> 00:42:39,330

just a glimpse of what might actually be

1064

00:42:47,480 --> 00:42:42,079

going on in Mars

1065

00:42:57,589 --> 00:42:47,490

I'm some that's a good question this is

1066

00:42:59,480 --> 00:42:57,599

sulfur chlorine bromine okay just

1067

00:43:01,190 --> 00:42:59,490

greatly surprising this when we get the

1068

00:43:06,319 --> 00:43:01,200

detail we find out it's really pretty

1069

00:43:08,630 --> 00:43:06,329

complicated I mean um that general trend

1070

00:43:10,849 --> 00:43:08,640

is not surprising but just the vast

1071

00:43:13,730 --> 00:43:10,859

degree of what we've seen in such a

1072

00:43:15,920 --> 00:43:13,740

small area and just the little bit just

1073

00:43:17,420 --> 00:43:15,930

a little our total ignorance from the

1074

00:43:19,520 --> 00:43:17,430

orbital observations that's what's

1075

00:43:21,589 --> 00:43:19,530

surprising i think just they explore the

1076

00:43:25,160 --> 00:43:21,599

extremeness of it or another way to ask

1077

00:43:28,760 --> 00:43:25,170

you for a typical area of the earth is

1078

00:43:30,349 --> 00:43:28,770

it less variety um you know nurse we

1079

00:43:32,960 --> 00:43:30,359

compared all the time the first round

1080

00:43:35,829 --> 00:43:32,970

truce vote improvements satellite stuff

1081

00:43:38,359 --> 00:43:35,839

well it matters where on earth I

1082

00:43:39,829 --> 00:43:38,369

actually would argue that in general if

1083

00:43:40,730 --> 00:43:39,839

you took any piece of ground on there if

1084

00:43:43,190 --> 00:43:40,740

you're not going to come across

1085

00:43:46,130 --> 00:43:43,200

something like this but then again gusev

1086

00:43:48,559 --> 00:43:46,140

was a really dull place until they

1087

00:43:51,170 --> 00:43:48,569

actually got to the Columbia Hills so

1088

00:43:53,630 --> 00:43:51,180

it's served like you're walking along

1089

00:43:54,559 --> 00:43:53,640

sort of a valley fill on the earth and

1090

00:43:56,270 --> 00:43:54,569

then all of a sudden you come across

1091

00:43:58,990 --> 00:43:56,280

coop right Nevada with all its

1092

00:44:02,569 --> 00:43:59,000

hydrothermal and other stuff going on

1093

00:44:04,040 --> 00:44:02,579

and um I think I'm at the final

1094

00:44:06,050 --> 00:44:04,050

composition chlorides with a big

1095

00:44:07,609 --> 00:44:06,060

question mark right next to it this has

1096

00:44:09,609 --> 00:44:07,619

been seen with the Themis data it's

1097

00:44:11,870 --> 00:44:09,619

characterized by low emissivity and

1098

00:44:13,579 --> 00:44:11,880

interesting sort of fractured patterns

1099

00:44:15,620 --> 00:44:13,589

and there's hundreds of exposure

1100

00:44:17,480 --> 00:44:15,630

exposures within the joaquin southern

1101

00:44:18,980 --> 00:44:17,490

highlands there's other explanations

1102

00:44:20,630 --> 00:44:18,990

possible i mainly put this up just

1103

00:44:21,800 --> 00:44:20,640

because there is new things coming up

1104

00:44:23,450 --> 00:44:21,810

that we're not understanding that

1105

00:44:27,319 --> 00:44:23,460

actually might be very important part of

1106

00:44:29,780 --> 00:44:27,329

this entire picture however if they are

1107

00:44:32,390 --> 00:44:29,790

chlorides like hey light which is just

1108

00:44:35,329 --> 00:44:32,400

basically table salt that's a whole new

1109

00:44:37,220 --> 00:44:35,339

sort of aqueous class of minerals that's

1110

00:44:42,380 --> 00:44:37,230

sort of a pattern that should be

1111

00:44:44,300 --> 00:44:42,390

recognized throughout Mars okay so let's

1112

00:44:47,390 --> 00:44:44,310

go back to our Martian compositional

1113

00:44:49,640 --> 00:44:47,400

history as it was proposed or call it

1114

00:44:51,079 --> 00:44:49,650

version 100 and we've got our pile of

1115

00:44:53,470 --> 00:44:51,089

silicate salt H and iron three-plus

1116

00:44:55,120 --> 00:44:53,480

weathering and sorry

1117

00:44:56,800 --> 00:44:55,130

this is as best as I can come up with

1118

00:44:59,200 --> 00:44:56,810

and it's it's actually really

1119

00:45:00,609 --> 00:44:59,210

complicated and I'm not I actually don't

1120

00:45:03,070 --> 00:45:00,619

think I understand it very well at this

1121

00:45:05,590 --> 00:45:03,080

point but I'm not sure anybody does so

1122

00:45:07,930 --> 00:45:05,600

if I have to try to make a new version

1123

00:45:09,340 --> 00:45:07,940

of this this is sort of the best thing I

1124

00:45:12,760 --> 00:45:09,350

can do is basically here's my version

1125

00:45:14,500 --> 00:45:12,770

101 where I modify some of these things

1126

00:45:16,570 --> 00:45:14,510

like associated more fish silica with

1127

00:45:17,950 --> 00:45:16,580

the sulfates and silica coatings and

1128

00:45:22,090 --> 00:45:17,960

Allah be weathering with the iron

1129

00:45:23,650 --> 00:45:22,100

three-plus this is sort of basically

1130

00:45:24,940 --> 00:45:23,660

okay yeah this is much much more

1131

00:45:26,349 --> 00:45:24,950

complicated and that's the point it's

1132

00:45:28,810 --> 00:45:26,359

not that you should trust any one of

1133

00:45:30,520 --> 00:45:28,820

these lines because I'm not sure I trust

1134

00:45:32,890 --> 00:45:30,530

myself which is the reason why there's

1135

00:45:35,170 --> 00:45:32,900

so many question marks here but a little

1136

00:45:37,720 --> 00:45:35,180

bit I think I that we do realize is that

1137

00:45:40,870 --> 00:45:37,730

this is this is an entire planet with an

1138

00:45:44,109 --> 00:45:40,880

entire sort of real complicated set of

1139

00:45:46,990 --> 00:45:44,119

different aqueous systems and the next

1140

00:45:51,070 --> 00:45:47,000

point I want to make was basically this

1141

00:45:53,920 --> 00:45:51,080

is point number two variable formation

1142

00:45:56,260 --> 00:45:53,930

environments and there's there tends to

1143

00:45:57,970 --> 00:45:56,270

be this this thinking of okay I'm seeing

1144

00:45:59,470 --> 00:45:57,980

sulfates here so I must not see

1145

00:46:01,180 --> 00:45:59,480

phyllosilicates because they don't form

1146

00:46:03,280 --> 00:46:01,190

in the same conditions in the first

1147

00:46:05,070 --> 00:46:03,290

order that's sort of correct and that's

1148

00:46:07,480 --> 00:46:05,080

actually as well as I understand myself

1149

00:46:11,890 --> 00:46:07,490

but you go out into the real world and

1150

00:46:13,950 --> 00:46:11,900

you see basically phyllosilicates right

1151

00:46:15,940 --> 00:46:13,960

juxtaposed right against sulfates

1152

00:46:19,330 --> 00:46:15,950

phyllosilicates and sulfates are not

1153

00:46:21,460 --> 00:46:19,340

mutually exclusive on or Mars and so

1154

00:46:23,770 --> 00:46:21,470

they can be forming contemporaneously

1155

00:46:26,920 --> 00:46:23,780

and in close proximity than one another

1156

00:46:28,510 --> 00:46:26,930

so this is Alice Baldrige gave me these

1157

00:46:30,580 --> 00:46:28,520

pictures this is like gilmore elf in

1158

00:46:32,440 --> 00:46:30,590

Western Australia out in the middle of

1159

00:46:34,599 --> 00:46:32,450

the lake we have low pH environments

1160

00:46:37,420 --> 00:46:34,609

where we're forming nice beautiful tool

1161

00:46:39,340 --> 00:46:37,430

sulphate crystals and if we go over to

1162

00:46:40,750 --> 00:46:39,350

the edge of the lake we have a moderate

1163

00:46:42,820 --> 00:46:40,760

to high pH environment where we're

1164

00:46:45,550 --> 00:46:42,830

forming phyllosilicate rich materials

1165

00:46:47,500 --> 00:46:45,560

and so this is sort of the type of

1166

00:46:49,510 --> 00:46:47,510

real-world situation that really does

1167

00:46:55,140 --> 00:46:49,520

occur and it's likely to have occurred

1168

00:46:58,359 --> 00:46:55,150

on Mars as well ok so the west and

1169

00:47:00,010 --> 00:46:58,369

hopefully relatively quickly going off

1170

00:47:02,140 --> 00:47:00,020

to linking conditions to have an ability

1171

00:47:04,060 --> 00:47:02,150

and preservation potential so I actually

1172

00:47:06,580 --> 00:47:04,070

want to make this relatively applicable

1173

00:47:07,059 --> 00:47:06,590

to the sort of they ask your biological

1174

00:47:10,989 --> 00:47:07,069

focus

1175

00:47:13,989 --> 00:47:10,999

here and in doing so I want to caution

1176  
00:47:16,749 --> 00:47:13,999  
you as to what I'm about to say I don't

1177  
00:47:20,319 --> 00:47:16,759  
typically this is this is where I know

1178  
00:47:21,999 --> 00:47:20,329  
the least to put it bluntly and so I'm

1179  
00:47:23,499 --> 00:47:22,009  
learning about this stuff you go to the

1180  
00:47:26,079 --> 00:47:23,509  
Mars Science Laboratory workshops you

1181  
00:47:27,430 --> 00:47:26,089  
under they basically that's probably the

1182  
00:47:30,459 --> 00:47:27,440  
goal of emissions to try to find

1183  
00:47:32,670 --> 00:47:30,469  
habitability and so I'm learning about

1184  
00:47:35,890 --> 00:47:32,680  
how the minerals themselves relate to

1185  
00:47:39,279 --> 00:47:35,900  
what conditions were and then how well

1186  
00:47:42,120 --> 00:47:39,289  
life would do there NP preserve and so

1187  
00:47:44,380 --> 00:47:42,130  
the first thing is in habitability is

1188  
00:47:46,299 --> 00:47:44,390

okay this is what we've always been told

1189

00:47:47,709 --> 00:47:46,309

liquid water you need liquid water for

1190

00:47:49,299 --> 00:47:47,719

life and so that's the first thing

1191

00:47:50,920 --> 00:47:49,309

that's the first question you asked and

1192

00:47:53,650 --> 00:47:50,930

that one's simple i think i understand

1193

00:47:56,380 --> 00:47:53,660

that one it requires mineralogical

1194

00:47:57,759 --> 00:47:56,390

evidence basically of clay sulfate

1195

00:48:00,459 --> 00:47:57,769

carbonates a lot of the things that i've

1196

00:48:02,049 --> 00:48:00,469

been talking about these things imply

1197

00:48:03,910 --> 00:48:02,059

the longer-term presence of liquid water

1198

00:48:05,589 --> 00:48:03,920

so if we had water washing across the

1199

00:48:07,209 --> 00:48:05,599

surface for a little while you probably

1200

00:48:08,589 --> 00:48:07,219

won't see much of a signature of it but

1201  
00:48:09,759 --> 00:48:08,599  
if it was around for a long time you can

1202  
00:48:11,680 --> 00:48:09,769  
dissolve a lot of stuff and when

1203  
00:48:14,410 --> 00:48:11,690  
precipitated out again whether things

1204  
00:48:15,939 --> 00:48:14,420  
and the other aspect of this is

1205  
00:48:18,579 --> 00:48:15,949  
morphological evidence which I'm not

1206  
00:48:20,170 --> 00:48:18,589  
going to dwell on too much but there's

1207  
00:48:22,779 --> 00:48:20,180  
plain morphological evidence as well

1208  
00:48:24,099 --> 00:48:22,789  
built up shorelines channels layers and

1209  
00:48:25,870 --> 00:48:24,109  
you look for evidence of sustained

1210  
00:48:28,299 --> 00:48:25,880  
activity let me and ring steam channels

1211  
00:48:30,670 --> 00:48:28,309  
or sedimentary sequences and optimally

1212  
00:48:32,920 --> 00:48:30,680  
you'd like to have both and so this is

1213  
00:48:36,699 --> 00:48:32,930

ever smelled greater this is interpreted

1214

00:48:39,729 --> 00:48:36,709

as basically reverse topography in a

1215

00:48:42,849 --> 00:48:39,739

built a deposit and their signatures of

1216

00:48:45,549 --> 00:48:42,859

increased hydration along the edges of

1217

00:48:47,289 --> 00:48:45,559

this deposit so this is one of the

1218

00:48:51,849 --> 00:48:47,299

proposed to Mars sanic the Mars Science

1219

00:48:53,849 --> 00:48:51,859

Laboratory walk shops workshop landing

1220

00:48:57,039 --> 00:48:53,859

sites what is reverse in topography

1221

00:48:59,529 --> 00:48:57,049

essentially if he deposited more

1222

00:49:01,059 --> 00:48:59,539

resistant material within a channel and

1223

00:49:04,120 --> 00:49:01,069

then you wrote did all the other stuff

1224

00:49:06,670 --> 00:49:04,130

around it so i er area shows you where a

1225

00:49:11,400 --> 00:49:06,680

stream yes exactly as long as that

1226  
00:49:14,249 --> 00:49:11,410  
hydrated sulfates if I was so kids um I

1227  
00:49:15,910 --> 00:49:14,259  
believe it was phyllo silicates

1228  
00:49:16,430 --> 00:49:15,920  
technically what we're looking at here

1229  
00:49:19,910 --> 00:49:16,440  
is

1230  
00:49:21,470 --> 00:49:19,920  
essentially the ralphs Milliken's he

1231  
00:49:23,210 --> 00:49:21,480  
determines the water content of a

1232  
00:49:24,859 --> 00:49:23,220  
surface by looking at the 3 micron

1233  
00:49:26,359 --> 00:49:24,869  
absorption and that's technically what's

1234  
00:49:29,510 --> 00:49:26,369  
being out here but I think he attributed

1235  
00:49:31,040 --> 00:49:29,520  
to phyllosilicates these are actually

1236  
00:49:34,010 --> 00:49:31,050  
quite small abundances they're going

1237  
00:49:40,160 --> 00:49:34,020  
from like three percent to maybe at the

1238  
00:49:41,750 --> 00:49:40,170

most ten percent hydration so taking

1239

00:49:43,700 --> 00:49:41,760

this habitability question and asking

1240

00:49:46,370 --> 00:49:43,710

some of second-order questions or maybe

1241

00:49:48,230 --> 00:49:46,380

first-order questions besides a whole

1242

00:49:50,120 --> 00:49:48,240

liquid water one is you want to look at

1243

00:49:52,609 --> 00:49:50,130

the oxidation pH environment energy

1244

00:49:54,400 --> 00:49:52,619

source nutrients and water activity

1245

00:49:57,920 --> 00:49:54,410

amongst probably many other things and

1246

00:49:59,720 --> 00:49:57,930

Dave Desmarais put this into a nice

1247

00:50:02,150 --> 00:49:59,730

little simplistic thing that I could

1248

00:50:05,150 --> 00:50:02,160

understand and thinking of just what you

1249

00:50:06,950 --> 00:50:05,160

call a habitability box essentially you

1250

00:50:08,300 --> 00:50:06,960

want nutrients but if you have too few

1251  
00:50:10,150 --> 00:50:08,310  
you'll starve if you have too many

1252  
00:50:12,859 --> 00:50:10,160  
you'll is basically a toxic environment

1253  
00:50:14,450 --> 00:50:12,869  
you can't have too much energy well the

1254  
00:50:16,970 --> 00:50:14,460  
things don't survive very rolling up

1255  
00:50:18,349 --> 00:50:16,980  
fire but if there's no energy to harness

1256  
00:50:21,530 --> 00:50:18,359  
well you're not going to have much to

1257  
00:50:23,270 --> 00:50:21,540  
live on and then water activity there

1258  
00:50:25,819 --> 00:50:23,280  
can be too little or you can just dilute

1259  
00:50:28,640 --> 00:50:25,829  
it too much and one thing that I really

1260  
00:50:32,750 --> 00:50:28,650  
sort of grasp on to is this whole water

1261  
00:50:35,720 --> 00:50:32,760  
activity concept which is something that

1262  
00:50:38,000 --> 00:50:35,730  
can be actually very nicely related back

1263  
00:50:42,079 --> 00:50:38,010

to the mineral composition of a surface

1264

00:50:43,550 --> 00:50:42,089

and this is summarized from Nick Tosca

1265

00:50:46,520 --> 00:50:43,560

had a paper that came out in science

1266

00:50:47,839 --> 00:50:46,530

this year where he basically looked at

1267

00:50:50,510 --> 00:50:47,849

the geochemistry of the Martian surface

1268

00:50:53,720 --> 00:50:50,520

as we know it or as we can presume it

1269

00:50:55,730 --> 00:50:53,730

might be and try to basically understand

1270

00:50:57,470 --> 00:50:55,740

what the water activity was what the

1271

00:50:59,150 --> 00:50:57,480

environment what the water activity was

1272

00:51:00,800 --> 00:50:59,160

in the environment and water activity is

1273

00:51:03,410 --> 00:51:00,810

essentially the chemical availability of

1274

00:51:05,660 --> 00:51:03,420

the water for example increasing the

1275

00:51:08,030 --> 00:51:05,670

salinity of the liquid basically

1276  
00:51:09,859 --> 00:51:08,040  
decreases the water activity and if it's

1277  
00:51:11,420 --> 00:51:09,869  
to say line you're not going to

1278  
00:51:13,400 --> 00:51:11,430  
basically life won't be able to survive

1279  
00:51:14,990 --> 00:51:13,410  
so he's got a couple of different points

1280  
00:51:18,200 --> 00:51:15,000  
he uses the Martian compositions to

1281  
00:51:20,420 --> 00:51:18,210  
predict the water activity and this is a

1282  
00:51:22,250 --> 00:51:20,430  
very important part of it is he argues

1283  
00:51:25,430 --> 00:51:22,260  
that Bryan's are not remnants of dilute

1284  
00:51:26,660 --> 00:51:25,440  
waters that evaporates subsequently and

1285  
00:51:28,970 --> 00:51:26,670  
I think he can still argue with that

1286  
00:51:30,170 --> 00:51:28,980  
point quite a bit but his argument was

1287  
00:51:32,360 --> 00:51:30,180  
these hands started out as

1288  
00:51:34,220 --> 00:51:32,370

lieut nice lakes that you could live in

1289

00:51:36,680 --> 00:51:34,230

very happily and then basically

1290

00:51:38,180 --> 00:51:36,690

evaporated away he's arguing that for

1291

00:51:42,200 --> 00:51:38,190

the most part in the deposits that we

1292

00:51:45,740 --> 00:51:42,210

see the water was concentrated pretty

1293

00:51:48,080 --> 00:51:45,750

much from the get-go and then he

1294

00:51:50,530 --> 00:51:48,090

distinguishes this is the other

1295

00:51:54,110 --> 00:51:50,540

important point he distinguishes between

1296

00:51:55,690 --> 00:51:54,120

originating in and adapting to a low

1297

00:51:57,980 --> 00:51:55,700

water activity environment and

1298

00:52:00,230 --> 00:51:57,990

essentially his argument is that low

1299

00:52:02,270 --> 00:52:00,240

activity of water inhibits prebiotic

1300

00:52:05,060 --> 00:52:02,280

chemistry and so if life were to try to

1301  
00:52:07,220 --> 00:52:05,070  
get started it would not do so very well

1302  
00:52:11,210 --> 00:52:07,230  
any low water activity environment and

1303  
00:52:12,820 --> 00:52:11,220  
so we have our essentially the chemistry

1304  
00:52:15,200 --> 00:52:12,830  
of the water the activity of the water

1305  
00:52:17,660 --> 00:52:15,210  
on different situations this is

1306  
00:52:20,090 --> 00:52:17,670  
meridiani planum the sulfate deposits

1307  
00:52:21,830 --> 00:52:20,100  
and meridiani this is knock lights these

1308  
00:52:23,660 --> 00:52:21,840  
are Martian meteorites which have some

1309  
00:52:25,910 --> 00:52:23,670  
evaporites in the Met low concentrations

1310  
00:52:28,550 --> 00:52:25,920  
and this is earth sea water so he

1311  
00:52:30,140 --> 00:52:28,560  
calculates basically the activity of the

1312  
00:52:34,340 --> 00:52:30,150  
water in the different situations in

1313  
00:52:36,860 --> 00:52:34,350

december i sat in the chart we have the

1314

00:52:39,250 --> 00:52:36,870

water activity values for the sulfates

1315

00:52:42,770 --> 00:52:39,260

at meridiani chlorides at meridiani

1316

00:52:44,060 --> 00:52:42,780

Martian meteorite brines and paso robles

1317

00:52:46,370 --> 00:52:44,070

which is in Goose have created at

1318

00:52:47,930 --> 00:52:46,380

Columbia Hills soil brines and comes up

1319

00:52:50,120 --> 00:52:47,940

with these numbers for water activity

1320

00:52:52,160 --> 00:52:50,130

which are actually quite very low and

1321

00:52:55,310 --> 00:52:52,170

for comparison if you're looking at

1322

00:52:57,620 --> 00:52:55,320

Earth organisms the limit is point nine

1323

00:52:59,660 --> 00:52:57,630

Cory extremophile like fungi archaea

1324

00:53:04,010 --> 00:52:59,670

point seven five and the actual limit

1325

00:53:05,570 --> 00:53:04,020

the record is point six one so I'm not I

1326  
00:53:07,160 --> 00:53:05,580  
guess what I'm not I'm not necessarily

1327  
00:53:08,450 --> 00:53:07,170  
saying that this you know wife will

1328  
00:53:10,370 --> 00:53:08,460  
never develop on Mars you can see water

1329  
00:53:13,190 --> 00:53:10,380  
activity is not good but the basic point

1330  
00:53:14,900 --> 00:53:13,200  
is this was a really nice concrete

1331  
00:53:16,940 --> 00:53:14,910  
example of where I can take the

1332  
00:53:20,330 --> 00:53:16,950  
mineralogy of Mars and directly apply it

1333  
00:53:25,970 --> 00:53:20,340  
to how life would develop endure survive

1334  
00:53:28,820 --> 00:53:25,980  
on the surface the second point and I'm

1335  
00:53:29,870 --> 00:53:28,830  
almost done is preservation potential so

1336  
00:53:32,630 --> 00:53:29,880  
not only do you have to have have

1337  
00:53:35,210 --> 00:53:32,640  
ability evett ability but whatever you

1338  
00:53:36,710 --> 00:53:35,220

grow in this environment has to stay

1339

00:53:38,990 --> 00:53:36,720

there for you to discover it later on

1340

00:53:41,060 --> 00:53:39,000

and so that brings up a whole new set of

1341

00:53:43,040 --> 00:53:41,070

conditions to consider once again water

1342

00:53:44,130 --> 00:53:43,050

activity but instead of a high number

1343

00:53:45,660 --> 00:53:44,140

you want to loan the

1344

00:53:48,660 --> 00:53:45,670

were to preserve it essentially you want

1345

00:53:51,390 --> 00:53:48,670

to pickle something permeability are you

1346

00:53:52,410 --> 00:53:51,400

able to wash it away temperature if you

1347

00:53:55,650 --> 00:53:52,420

bury it too deep you're going to

1348

00:53:59,310 --> 00:53:55,660

basically decompose things oxidation

1349

00:54:01,020 --> 00:53:59,320

potential you generally don't want to

1350

00:54:02,970 --> 00:54:01,030

oxidize it so you don't want exposed to

1351  
00:54:05,400 --> 00:54:02,980  
say UV radiation right at the surface of

1352  
00:54:07,800 --> 00:54:05,410  
Mars and then exclamation you want it to

1353  
00:54:09,510 --> 00:54:07,810  
be exposed at the surface so you want it

1354  
00:54:13,290 --> 00:54:09,520  
to be at the surface but not for too

1355  
00:54:15,180 --> 00:54:13,300  
long and this is cut off at the bottom

1356  
00:54:16,590 --> 00:54:15,190  
here but basically it's like this is a

1357  
00:54:19,080 --> 00:54:16,600  
whole new set of conditions that you

1358  
00:54:20,970 --> 00:54:19,090  
need to look into in order to basically

1359  
00:54:24,990 --> 00:54:20,980  
figure out okay where am I going to go

1360  
00:54:27,780 --> 00:54:25,000  
on Mars in order to find any remnants of

1361  
00:54:29,220 --> 00:54:27,790  
life and the the mineralogy of the

1362  
00:54:31,410 --> 00:54:29,230  
surface not only has something to say

1363  
00:54:34,490 --> 00:54:31,420

about the habitability but also whether

1364

00:54:37,770 --> 00:54:34,500

or not it's actually preserved and so

1365

00:54:39,660 --> 00:54:37,780

essentially to conclude the conclusion

1366

00:54:43,350 --> 00:54:39,670

is sort of a non conclusion it's

1367

00:54:45,420 --> 00:54:43,360

basically stay tuned we've got this a

1368

00:54:47,430 --> 00:54:45,430

wide variety of compositions on the

1369

00:54:48,600 --> 00:54:47,440

surface it's weird starting to

1370

00:54:50,880 --> 00:54:48,610

understand that much better it's a

1371

00:54:52,890 --> 00:54:50,890

growing list and what I think it tells

1372

00:54:54,660 --> 00:54:52,900

us is that there's a variety of code

1373

00:54:56,330 --> 00:54:54,670

temporal aqueous environments on the

1374

00:54:58,500 --> 00:54:56,340

planet that shouldn't be a surprise

1375

00:55:01,260 --> 00:54:58,510

that's something that we should be very

1376  
00:55:02,790 --> 00:55:01,270  
aware of and then much remains to be

1377  
00:55:05,790 --> 00:55:02,800  
discovered in more fully characterized

1378  
00:55:07,200 --> 00:55:05,800  
as I said so the big question is where

1379  
00:55:10,380 --> 00:55:07,210  
is habitability and preservation

1380  
00:55:11,520 --> 00:55:10,390  
potential maximized and that's why I

1381  
00:55:13,590 --> 00:55:11,530  
want to talk about the Mars Science

1382  
00:55:15,720 --> 00:55:13,600  
Laboratory here is basically the landing

1383  
00:55:19,110 --> 00:55:15,730  
site selection process has been all

1384  
00:55:21,030 --> 00:55:19,120  
about this question and much of it

1385  
00:55:22,770 --> 00:55:21,040  
revolves around the morphology of the

1386  
00:55:24,270 --> 00:55:22,780  
surface but much of it also revolves

1387  
00:55:25,830 --> 00:55:24,280  
around the mineralogy of the surface so

1388  
00:55:27,870 --> 00:55:25,840

taking the mineralogy of the surface the

1389

00:55:30,350 --> 00:55:27,880

composition to try to answer this

1390

00:55:34,310 --> 00:55:30,360

question to figure out where to send the

1391

00:55:38,280 --> 00:55:34,320

1.8 billion dollar lander in growing is

1392

00:55:40,260 --> 00:55:38,290

is it's basically the question to ask

1393

00:55:42,270 --> 00:55:40,270

and that's why this stuff is important

1394

00:55:49,190 --> 00:55:42,280

and I think I'm going to stop there so

1395

00:55:55,620 --> 00:55:54,690

questions Erica you mentioned that we're

1396

00:55:57,359 --> 00:55:55,630

going you're talking about the different

1397

00:55:59,460 --> 00:55:57,369

detectors and you're pointing out that

1398

00:56:01,230 --> 00:55:59,470

prism has sort of the optimal thing and

1399

00:56:03,150 --> 00:56:01,240

that it's high spatial resolution with

1400

00:56:05,100 --> 00:56:03,160

high spectral resolution but the

1401  
00:56:07,950 --> 00:56:05,110  
trade-off is you get a really small area

1402  
00:56:11,310 --> 00:56:07,960  
to see how long will it take for prism

1403  
00:56:15,030 --> 00:56:11,320  
to map the entire surface um essentially

1404  
00:56:17,040 --> 00:56:15,040  
forever Oh chrism they've done a couple

1405  
00:56:18,480 --> 00:56:17,050  
of neat things in that that's always a

1406  
00:56:20,160 --> 00:56:18,490  
trade-off and how many bits can you send

1407  
00:56:22,080 --> 00:56:20,170  
back to earth as well and that you know

1408  
00:56:25,109 --> 00:56:22,090  
mro it's got this nice big huge antenna

1409  
00:56:26,370 --> 00:56:25,119  
with a just a wonderful data rate they

1410  
00:56:28,260 --> 00:56:26,380  
also have essentially what they call a

1411  
00:56:31,109 --> 00:56:28,270  
multispectral milligram only sent send

1412  
00:56:33,990 --> 00:56:31,119  
back 70 bands rather than 500 bands and

1413  
00:56:35,880 --> 00:56:34,000

they some things to roughly 100 meter

1414

00:56:37,650 --> 00:56:35,890

per pixel resolution so it's

1415

00:56:40,080 --> 00:56:37,660

continuously taking strips and will

1416

00:56:41,870 --> 00:56:40,090

build up a planetary picture but those

1417

00:56:44,730 --> 00:56:41,880

little postage stamps which I showed

1418

00:56:46,320 --> 00:56:44,740

won't probably cover much more than I

1419

00:56:48,300 --> 00:56:46,330

don't know maybe not more than ten

1420

00:56:54,780 --> 00:56:48,310

percent of the planet over the course of

1421

00:56:56,310 --> 00:56:54,790

extended missions first of all this is a

1422

00:56:59,910 --> 00:56:56,320

marvelous example of a great

1423

00:57:02,520 --> 00:56:59,920

astrobiology talk dipped in for the

1424

00:57:05,420 --> 00:57:02,530

geologist but you kept in general was

1425

00:57:10,320 --> 00:57:05,430

Restless a lot of great information

1426  
00:57:13,410 --> 00:57:10,330  
summarize liquid water today he's caught

1427  
00:57:17,849 --> 00:57:13,420  
a lot about this what do you think of

1428  
00:57:21,690 --> 00:57:17,859  
the odds version look um well very

1429  
00:57:25,260 --> 00:57:21,700  
deeply where you can't access it the one

1430  
00:57:27,990 --> 00:57:25,270  
interest pumping on the order of

1431  
00:57:29,700 --> 00:57:28,000  
hundreds of meters to kilometers in the

1432  
00:57:31,200 --> 00:57:29,710  
equatorial regions those places where

1433  
00:57:32,400 --> 00:57:31,210  
they do predict liquid water to be

1434  
00:57:34,530 --> 00:57:32,410  
present we don't know if it's actually

1435  
00:57:37,500 --> 00:57:34,540  
there or not could be if you can drill

1436  
00:57:40,109 --> 00:57:37,510  
deeply enough to get to it but I that's

1437  
00:57:41,490 --> 00:57:40,119  
one thing that we do see is the gullies

1438  
00:57:43,950 --> 00:57:41,500

and I'm not sure how much people know

1439

00:57:45,240 --> 00:57:43,960

about Kelly's they're essentially stream

1440

00:57:46,470 --> 00:57:45,250

channels on the sides of craters or

1441

00:57:48,300 --> 00:57:46,480

whatever that have essentially no

1442

00:57:49,710 --> 00:57:48,310

craters on them and they've taken before

1443

00:57:52,650 --> 00:57:49,720

and after picture is seeing them

1444

00:57:54,300 --> 00:57:52,660

actually form and there's alternate

1445

00:57:56,099 --> 00:57:54,310

hypotheses but I think most people

1446

00:57:57,960 --> 00:57:56,109

generally sort of agree with the it's

1447

00:57:59,490 --> 00:57:57,970

probably liquid water that forms

1448

00:58:03,450 --> 00:57:59,500

many of the legalities that we see and

1449

00:58:04,859 --> 00:58:03,460

so essentially we think liquid water is

1450

00:58:06,359 --> 00:58:04,869

flowing on the surface of cars today

1451

00:58:08,070 --> 00:58:06,369

it's not stable on the surface so it

1452

00:58:10,680 --> 00:58:08,080

doesn't last very long so if you

1453

00:58:12,480 --> 00:58:10,690

identify one of those regions you can

1454

00:58:14,820 --> 00:58:12,490

probably access it very close to the

1455

00:58:18,810 --> 00:58:14,830

surface if not like just stand there and

1456

00:58:21,839 --> 00:58:18,820

wait for it to happen how I don't know

1457

00:58:24,300 --> 00:58:21,849

it's but you haven't mentioned in

1458

00:58:28,920 --> 00:58:24,310

geothermal possible hospital it would be

1459

00:58:32,190 --> 00:58:28,930

super deep it's possible we know about

1460

00:58:34,980 --> 00:58:32,200

that you're saying we can rule out that

1461

00:58:36,480 --> 00:58:34,990

they can't be liquid water say is 200

1462

00:58:39,000 --> 00:58:36,490

meters because we made the thermal mass

1463

00:58:40,500 --> 00:58:39,010

there just isn't the chili well it'd be

1464

00:58:42,060 --> 00:58:40,510

tough knowing whether or not you detect

1465

00:58:43,830 --> 00:58:42,070

it or not actually one thing I do with

1466

00:58:46,770 --> 00:58:43,840

the Themis data its hundred meters per

1467

00:58:48,599 --> 00:58:46,780

pixel and I look at it when itself it

1468

00:58:51,300 --> 00:58:48,609

with an algorithm basically looking for

1469

00:58:52,770 --> 00:58:51,310

hot pixels and I've covered the surface

1470

00:58:54,930 --> 00:58:52,780

over and over and over again looking for

1471

00:58:56,370 --> 00:58:54,940

that you know it's a one in you know one

1472

00:58:58,320 --> 00:58:56,380

in a hundred chance of discovering

1473

00:58:59,609 --> 00:58:58,330

something like that which is probably

1474

00:59:01,109 --> 00:58:59,619

worth it it's really it would be a

1475

00:59:03,270 --> 00:59:01,119

really great discovery but nothing's

1476

00:59:06,210 --> 00:59:03,280

shown up but that's you know a full

1477

00:59:09,329 --> 00:59:06,220

hundred meters square pixel well above

1478

00:59:10,740 --> 00:59:09,339

the background temperature and so you

1479

00:59:13,440 --> 00:59:10,750

know at what level would you discover

1480

00:59:14,820 --> 00:59:13,450

something I'm sure there's got to be

1481

00:59:21,810 --> 00:59:14,830

something that exists on the surface

1482

00:59:25,410 --> 00:59:21,820

that's a hot spot cub oh so I'm actually

1483

00:59:27,240 --> 00:59:25,420

pretty interested in the sources of a

1484

00:59:30,800 --> 00:59:27,250

lot of these minerals they could be

1485

00:59:33,900 --> 00:59:30,810

Halloween perhaps even early stages and

1486

00:59:37,020 --> 00:59:33,910

hematite formations whole phase and what

1487

00:59:39,690 --> 00:59:37,030

this might mean to but what Mars look

1488

00:59:44,730 --> 00:59:39,700

like I must say is surely no argument

1489

00:59:46,170 --> 00:59:44,740

and norm sleep invention that is that

1490

00:59:49,530 --> 00:59:46,180

very early period you might have at a

1491

00:59:51,660 --> 00:59:49,540

short period of plate tectonics for

1492

00:59:55,020 --> 00:59:51,670

example and that would have contributed

1493

00:59:58,170 --> 00:59:55,030

for example to making a state of course

1494

01:00:00,230 --> 00:59:58,180

evolving but I want to get your thoughts

1495

01:00:06,050 --> 01:00:00,240

on the sources of those

1496

01:00:09,650 --> 01:00:06,060

and secondly how those methane to write

1497

01:00:11,120 --> 01:00:09,660

so the sources of keep my notes I could

1498

01:00:14,240 --> 01:00:11,130

give it entirely separate talk on

1499

01:00:15,560 --> 01:00:14,250

igneous compositions on ours not that I

1500

01:00:20,630 --> 01:00:15,570

understand that you more about that than

1501

01:00:22,070 --> 01:00:20,640

I do about this but it's what I'm having

1502

01:00:24,170 --> 01:00:22,080

trouble with and what I'm served just

1503

01:00:26,420 --> 01:00:24,180

realized over the last year with service

1504

01:00:28,190 --> 01:00:26,430

all of the dissolution stuff is I don't

1505

01:00:30,140 --> 01:00:28,200

even know where we started in terms of

1506

01:00:33,860 --> 01:00:30,150

igneous compositions you have the snc

1507

01:00:35,330 --> 01:00:33,870

meteorites which do not look like much

1508

01:00:37,400 --> 01:00:35,340

of the rest of the surface of Mars does

1509

01:00:39,050 --> 01:00:37,410

from the remote sensing and then you

1510

01:00:41,660 --> 01:00:39,060

have these very olivene registered p

1511

01:00:45,470 --> 01:00:41,670

critic basalts which sort of fall into

1512

01:00:47,900 --> 01:00:45,480

the ultramafic category um to be honest

1513

01:00:50,210 --> 01:00:47,910

I I'm sort of clueless as to what sort

1514

01:00:52,040 --> 01:00:50,220

of mechanisms you have for forming es

1515

01:00:54,440 --> 01:00:52,050

compositions and then there's I didn't

1516

01:00:56,180 --> 01:00:54,450

talk about but there's sort of areas

1517

01:00:59,920 --> 01:00:56,190

where you have sending essentially

1518

01:01:02,180 --> 01:00:59,930

granitic compositions and how you what

1519

01:01:04,010 --> 01:01:02,190

mechanism is going on to differentiate

1520

01:01:07,010 --> 01:01:04,020

the you know the manual competition to

1521

01:01:09,950 --> 01:01:07,020

get such a high silica competition uh so

1522

01:01:12,970 --> 01:01:09,960

yeah the answer is I have no idea and

1523

01:01:16,820 --> 01:01:12,980

then how does methane fit into this

1524

01:01:20,690 --> 01:01:16,830

that's also a good question i don't know

1525

01:01:22,370 --> 01:01:20,700

that it's obviously important everybody

1526

01:01:25,550 --> 01:01:22,380

links methane to at least the

1527

01:01:27,110 --> 01:01:25,560

possibility of light the detection czar

1528

01:01:29,480 --> 01:01:27,120

getting a little bit more confident at

1529

01:01:32,110 --> 01:01:29,490

least mike mama it's starting to look at

1530

01:01:35,480 --> 01:01:32,120

spatial distributions and other things

1531

01:01:37,280 --> 01:01:35,490

but as to until you actually kneel down

1532

01:01:39,260 --> 01:01:37,290

the source and see exactly where it's

1533

01:01:40,970 --> 01:01:39,270

coming from i don't know that any you

1534

01:01:43,460 --> 01:01:40,980

can't just do anything but just kind of

1535

01:01:44,010 --> 01:01:43,470

wildly speculate on it yeah just wonder

1536

01:01:46,770 --> 01:01:44,020

if it was

1537

01:01:49,140 --> 01:01:46,780

anybody has actually mapped out where if

1538

01:01:53,370 --> 01:01:49,150

there are hot sbux for methane do they

1539

01:01:56,720 --> 01:01:53,380

overlay some other zones of the five

1540

01:02:01,620 --> 01:01:56,730

minerals for example the hydrated yeah

1541

01:02:03,930 --> 01:02:01,630

husband and it would be they have like

1542

01:02:05,970 --> 01:02:03,940

the last Scout proposals they purple of

1543

01:02:07,500 --> 01:02:05,980

different teams proposed really really

1544

01:02:10,080 --> 01:02:07,510

sensitive spectrometer is that would

1545

01:02:11,820 --> 01:02:10,090

basically zero in on exactly where the

1546

01:02:14,070 --> 01:02:11,830

methane was that Serb orders of

1547

01:02:16,070 --> 01:02:14,080

magnitude more precise precision than

1548

01:02:18,570 --> 01:02:16,080

what we have now but we're not there yet

1549

01:02:22,290 --> 01:02:18,580

it's just the question right now is is

1550

01:02:25,050 --> 01:02:22,300

there methane or not on Mars let's take

1551

01:02:28,800 --> 01:02:25,060

a remote question Oh NASA Ames that's a

1552

01:02:30,330 --> 01:02:28,810

question hi Josh I this is Dave and I

1553

01:02:33,210 --> 01:02:30,340

want to echo the comment that's a great

1554

01:02:35,550 --> 01:02:33,220

talk very very rich with information and

1555

01:02:38,520 --> 01:02:35,560

very clear the question I'd like to ask

1556

01:02:40,710 --> 01:02:38,530

is this one of difficulty in detecting a

1557

01:02:43,530 --> 01:02:40,720

lot of these features on the surface and

1558

01:02:44,760 --> 01:02:43,540

of course at the spirit site at Columbia

1559

01:02:47,130 --> 01:02:44,770

Hill site that you mentioned we

1560

01:02:49,140 --> 01:02:47,140

witnessed firsthand how atmospheric dust

1561

01:02:51,180 --> 01:02:49,150

settling just totally covers things up

1562

01:02:53,610 --> 01:02:51,190

all those silica deposits now you cannot

1563

01:02:56,520 --> 01:02:53,620

see any more even after we dragged him

1564

01:02:58,200 --> 01:02:56,530

up with the wheels so this dust settling

1565

01:02:59,670 --> 01:02:58,210

is really a major issue and I was

1566

01:03:02,370 --> 01:02:59,680

wondering if you could had some thoughts

1567

01:03:05,100 --> 01:03:02,380

about future orbital missions how can we

1568

01:03:06,780 --> 01:03:05,110

beat this problem back what have you

1569

01:03:09,000 --> 01:03:06,790

given any thought as to how we can make

1570

01:03:10,890 --> 01:03:09,010

the orbital remote sensing may be more

1571

01:03:14,820 --> 01:03:10,900

effective in coping with this dust

1572

01:03:18,390 --> 01:03:14,830

settling problem um that's a good thing

1573

01:03:21,150 --> 01:03:18,400

really difficult question um to be

1574

01:03:22,920 --> 01:03:21,160

honest the general feeling that I have

1575

01:03:26,250 --> 01:03:22,930

and I think a lot of others have this is

1576

01:03:28,430 --> 01:03:26,260

typically is covered with dust I have to

1577

01:03:32,310 --> 01:03:28,440

look elsewhere if I'm looking for morbid

1578

01:03:35,370 --> 01:03:32,320

I think one thing that helps get around

1579

01:03:36,750 --> 01:03:35,380

was get around it is say like the GRS

1580

01:03:39,540 --> 01:03:36,760

instrument is actually a really good

1581

01:03:42,090 --> 01:03:39,550

example both the neutron spectrometer in

1582

01:03:44,040 --> 01:03:42,100

the gamma ray spectrometer they show you

1583

01:03:45,360 --> 01:03:44,050

know things that are buried and yeah

1584

01:03:46,180 --> 01:03:45,370

it's at six hundred kilometer resolution

1585

01:03:48,100 --> 01:03:46,190

but

1586

01:03:50,500 --> 01:03:48,110

you can improve upon that type of thing

1587

01:03:52,000 --> 01:03:50,510

or find other sort of remote methods of

1588

01:03:53,830 --> 01:03:52,010

getting at composition I think that

1589

01:03:55,990 --> 01:03:53,840

helps although I don't know if you'll

1590

01:04:02,230 --> 01:03:56,000

ever get at that at the really high

1591

01:04:03,640 --> 01:04:02,240

level of spatial resolution so I I guess

1592

01:04:05,890 --> 01:04:03,650

the answer is I don't really know I

1593

01:04:07,510 --> 01:04:05,900

don't really have a good sense of what

1594

01:04:14,350 --> 01:04:07,520

what you would do otherwise other than

1595

01:04:17,980 --> 01:04:14,360

try different techniques don't you have

1596

01:04:21,910 --> 01:04:17,990

a question I said a question about these

1597

01:04:24,280 --> 01:04:21,920

seems general areas I mean the back the

1598

01:04:29,040 --> 01:04:24,290

silica deposit just sounded about the

1599

01:04:37,720 --> 01:04:36,010

interesting hey and it's it I it's

1600

01:04:44,290 --> 01:04:37,730

disturbing the number of things that the

1601  
01:04:47,770 --> 01:04:44,300  
wheels have dug up carbonates are

1602  
01:04:52,120 --> 01:04:47,780  
they're missing carbons on Mars uh I

1603  
01:04:54,430 --> 01:04:52,130  
don't think so I mean I can't tell you

1604  
01:04:55,720 --> 01:04:54,440  
for sure you just sort of give a minute

1605  
01:04:58,240 --> 01:04:55,730  
or two summary of how you see the

1606  
01:05:01,600 --> 01:04:58,250  
situation um carbonates seem to be

1607  
01:05:03,880 --> 01:05:01,610  
present like I'm between Phoenix and

1608  
01:05:06,310 --> 01:05:03,890  
tests at least they're pointed him with

1609  
01:05:09,030 --> 01:05:06,320  
one another so I think it might gain

1610  
01:05:12,400 --> 01:05:09,040  
strength as to being more of a credible

1611  
01:05:15,160 --> 01:05:12,410  
detection and but that's yeah low levels

1612  
01:05:17,590 --> 01:05:15,170  
but you sort of ubiquitous so where the

1613  
01:05:21,430 --> 01:05:17,600

you know where the white cliffs of Dover

1614

01:05:22,870 --> 01:05:21,440

on Mars and we don't see them which you

1615

01:05:24,520 --> 01:05:22,880

know given what I've been talking about

1616

01:05:26,620 --> 01:05:24,530

today you guys might not believe me that

1617

01:05:28,840 --> 01:05:26,630

I don't think that they're there one

1618

01:05:31,330 --> 01:05:28,850

thing that chrism has talked about at

1619

01:05:33,490 --> 01:05:31,340

the Mars Science Laboratory workshop is

1620

01:05:37,210 --> 01:05:33,500

they are seeing sort of what they

1621

01:05:40,900 --> 01:05:37,220

believe our minor layers of carbonates

1622

01:05:43,090 --> 01:05:40,910

in say the newly faucet region and once

1623

01:05:46,660 --> 01:05:43,100

again that's sort of in the area of well

1624

01:05:48,520 --> 01:05:46,670

that's not really i mean it's it's

1625

01:05:52,960 --> 01:05:48,530

interesting but i haven't seen enough to

1626

01:05:54,310 --> 01:05:52,970

say hey this is defended so if we're

1627

01:05:56,830 --> 01:05:54,320

starting to detect them in certain

1628

01:05:57,609 --> 01:05:56,840

places maybe they are sort of more

1629

01:05:59,230 --> 01:05:57,619

extensive

1630

01:06:01,180 --> 01:05:59,240

but in other cases like where you have

1631

01:06:03,339 --> 01:06:01,190

vast amounts of you no sulfates for

1632

01:06:04,870 --> 01:06:03,349

example like meridiani you really

1633

01:06:09,640 --> 01:06:04,880

wouldn't expect to see them in that

1634

01:06:12,579 --> 01:06:09,650

enough in those situations um you don't

1635

01:06:14,950 --> 01:06:12,589

see it as a great mystery you know given

1636

01:06:17,529 --> 01:06:14,960

the data that we have the lack of the

1637

01:06:21,309 --> 01:06:17,539

White Cliffs or something halfway to the

1638

01:06:24,220 --> 01:06:21,319

legs this I I actually don't see it as a

1639

01:06:25,930 --> 01:06:24,230

great mystery although maybe I mean

1640

01:06:27,789 --> 01:06:25,940

obviously you know when you think of

1641

01:06:28,779 --> 01:06:27,799

being a water and oceans on Mars and

1642

01:06:30,549 --> 01:06:28,789

things like that the first thing people

1643

01:06:33,730 --> 01:06:30,559

think about it yeah where the carbonate

1644

01:06:35,529 --> 01:06:33,740

deposits but maybe I'm not thinking

1645

01:06:38,589 --> 01:06:35,539

about it hard enough but in my mind it's

1646

01:06:41,140 --> 01:06:38,599

sort of well the geochemistry wasn't

1647

01:06:42,819 --> 01:06:41,150

right for for it remember that almost

1648

01:06:47,289 --> 01:06:42,829

all the carbonate deposits on earth were

1649

01:06:49,450 --> 01:06:47,299

biologically deposited right I've got

1650

01:06:52,720 --> 01:06:49,460

renewed when you say granitic do you

1651  
01:06:54,370 --> 01:06:52,730  
mean compositionally and I mean

1652  
01:06:55,839 --> 01:06:54,380  
mineralogical and textual are you

1653  
01:06:58,059 --> 01:06:55,849  
talking about a gross chemical

1654  
01:06:59,950 --> 01:06:58,069  
composition where it gets silicon mixing

1655  
01:07:03,430 --> 01:06:59,960  
with other stuff I'm talking about

1656  
01:07:05,620 --> 01:07:03,440  
mineral logically so I can't see that

1657  
01:07:09,009 --> 01:07:05,630  
you know I don't see I can't see the

1658  
01:07:11,319 --> 01:07:09,019  
texture on the surface I'm just seeing

1659  
01:07:14,650 --> 01:07:11,329  
the basically the spectral signature of

1660  
01:07:18,249 --> 01:07:14,660  
something that's basically composed of a

1661  
01:07:19,720 --> 01:07:18,259  
bulk of quartz and feldspar and even

1662  
01:07:23,470 --> 01:07:19,730  
then it starts to get vague about what

1663  
01:07:25,509 --> 01:07:23,480

kind of feldspar however that being said

1664

01:07:27,999 --> 01:07:25,519

the one thing I argued very strongly

1665

01:07:29,799 --> 01:07:28,009

about it is ok you can alter that you

1666

01:07:31,569 --> 01:07:29,809

can do various things with it it may not

1667

01:07:33,579 --> 01:07:31,579

be a grant grant it might be a nice it

1668

01:07:35,650 --> 01:07:33,589

might have been altered since then my or

1669

01:07:37,920 --> 01:07:35,660

whatever but it's hard to get that

1670

01:07:43,380 --> 01:07:37,930

composition without starting off with a

1671

01:07:46,359 --> 01:07:43,390

highly vault magma so I'm talking about

1672

01:07:49,690 --> 01:07:46,369

composition oh yeah if you ever truly

1673

01:07:53,499 --> 01:07:49,700

frenetic rock I've agree with you it

1674

01:07:58,269 --> 01:07:53,509

could be that you just have silica the

1675

01:08:00,970 --> 01:07:58,279

positive in rocks that have some other

1676

01:08:07,180 --> 01:08:00,980

compositions so the bulk composition is

1677

01:08:08,829 --> 01:08:07,190

a probe into granite um no I guess I

1678

01:08:10,270 --> 01:08:08,839

would argue against it because you know

1679

01:08:11,950 --> 01:08:10,280

right next to this you have

1680

01:08:14,530 --> 01:08:11,960

ultra compositions and so you have this

1681

01:08:17,890 --> 01:08:14,540

very nice isolated surface that's

1682

01:08:19,930 --> 01:08:17,900

composed of education courts and I I

1683

01:08:23,170 --> 01:08:19,940

can't think of a geological situation

1684

01:08:24,760 --> 01:08:23,180

where you can mix things in or or do

1685

01:08:27,010 --> 01:08:24,770

whatever without starting off with

1686

01:08:29,860 --> 01:08:27,020

basically a high social sports not a

1687

01:08:33,160 --> 01:08:29,870

more socially no definitely courts not

1688

01:08:39,789 --> 01:08:33,170

amorphous silica I can't tell you if its

1689

01:08:42,010 --> 01:08:39,799

case bar not but so I this I won't say

1690

01:08:43,690 --> 01:08:42,020

anything very very concretely about it

1691

01:08:46,300 --> 01:08:43,700

other than that and i think that's

1692

01:08:49,140 --> 01:08:46,310

defendable note final question anybody

1693

01:08:51,490 --> 01:08:49,150

yeah you gave a lot of cool examples of

1694

01:08:53,349 --> 01:08:51,500

minerals or Meteorology's that may have

1695

01:08:56,410 --> 01:08:53,359

formed in the presence of liquid water

1696

01:08:58,840 --> 01:08:56,420

you briefly mentioned these nanophase

1697

01:09:01,120 --> 01:08:58,850

iron oxide as a sort of a reverse

1698

01:09:04,150 --> 01:09:01,130

constraint you I think you said these

1699

01:09:06,280 --> 01:09:04,160

things would not be here if water had

1700

01:09:08,590 --> 01:09:06,290

flung or RF water hadn't have been

1701

01:09:09,880 --> 01:09:08,600

present so are there will aid and I get

1702

01:09:13,059 --> 01:09:09,890

that right and B are there other

1703

01:09:15,250 --> 01:09:13,069

mineralogy as you can point to that say

1704

01:09:18,460 --> 01:09:15,260

there was no water here and has a bit

1705

01:09:21,099 --> 01:09:18,470

for X amount right um well as far as I

1706

01:09:23,530 --> 01:09:21,109

understand as nanophase iron oxide form

1707

01:09:25,930 --> 01:09:23,540

they generally form in extremely limited

1708

01:09:29,380 --> 01:09:25,940

amounts of water and what that exactly

1709

01:09:32,740 --> 01:09:29,390

means it's not really well known but you

1710

01:09:35,980 --> 01:09:32,750

know it's not an ocean but yeah there's

1711

01:09:38,140 --> 01:09:35,990

other sort of examples I guess the way

1712

01:09:39,789 --> 01:09:38,150

I'd put it there's you know it's a

1713

01:09:42,190 --> 01:09:39,799

desert environment and you get sort of

1714

01:09:45,099 --> 01:09:42,200

some oxidation of surfaces you get

1715

01:09:47,289 --> 01:09:45,109

coatings on surfaces these are all sort

1716

01:09:48,940 --> 01:09:47,299

of indicative of dry environments in one

1717

01:09:49,809 --> 01:09:48,950

of the big questions in Mars Science

1718

01:09:52,840 --> 01:09:49,819

when you're looking at these

1719

01:09:54,790 --> 01:09:52,850

compositions so is if you go out to say

1720

01:09:57,570 --> 01:09:54,800

like the Atacama Desert where it rains

1721

01:10:00,640 --> 01:09:57,580

once a hundred years or whatever is that

1722

01:10:02,140 --> 01:10:00,650

you don't the processes are so slow

1723

01:10:04,240 --> 01:10:02,150

they're hard to recreate in a laboratory

1724

01:10:06,490 --> 01:10:04,250

and they're hard to see on earth without

1725

01:10:09,070 --> 01:10:06,500

just the overprinting of that once in a

1726  
01:10:10,510 --> 01:10:09,080  
hundred years rainstorm and so what

1727  
01:10:13,060 --> 01:10:10,520  
exactly this means about how little

1728  
01:10:15,760 --> 01:10:13,070  
water was there is still big but that

1729  
01:10:17,710 --> 01:10:15,770  
being said it does mean that I mean in a

1730  
01:10:19,540 --> 01:10:17,720  
relative sense there is little water

1731  
01:10:21,880 --> 01:10:19,550  
there if you look at it like the now

1732  
01:10:22,960 --> 01:10:21,890  
phase oxide like an oxidized you know

1733  
01:10:24,040 --> 01:10:22,970  
red soil sir

1734  
01:10:26,620 --> 01:10:24,050  
and he compared it with the

1735  
01:10:28,570 --> 01:10:26,630  
phyllosilicates one definitely screams

1736  
01:10:30,640 --> 01:10:28,580  
at you there's a lot of water here and

1737  
01:10:34,960 --> 01:10:30,650  
this one screams there wasn't a lot of

1738  
01:10:39,160 --> 01:10:34,970

water here well being another indicator

1739

01:10:41,200 --> 01:10:39,170

of new water often that was sort of Phil

1740

01:10:42,520 --> 01:10:41,210

Christensen's big thing hey there's

1741

01:10:45,640 --> 01:10:42,530

olivene on the surface it must have been

1742

01:10:47,170 --> 01:10:45,650

dry and to some degree he's right into

1743

01:10:50,230 --> 01:10:47,180

it but I think you can carry the

1744

01:10:51,580 --> 01:10:50,240

argument too far as well yeah if you

1745

01:10:53,380 --> 01:10:51,590

have unwedded olivene sitting on the

1746

01:10:55,720 --> 01:10:53,390

surface you probably haven't had a lot

1747

01:10:58,660 --> 01:10:55,730

of water but there's unweathered olivene

1748

01:11:02,710 --> 01:10:58,670

sitting on the surface of the earth with