
Momotombo

1
00:00:11,680 --> 00:00:08,560
yes thank you Mike and all of the

2
00:00:14,439 --> 00:00:11,690
organizing committee so we are going to

3
00:00:17,760 --> 00:00:14,449
time to talk about a lot of some of the

4
00:00:20,260 --> 00:00:17,770
terms we've heard today sulfates

5
00:00:22,480 --> 00:00:20,270
alteration and specifically I'm going to

6
00:00:23,800 --> 00:00:22,490
talk about Nicaragua before i get into

7
00:00:27,460 --> 00:00:23,810
the science i just want to acknowledge

8
00:00:30,609 --> 00:00:27,470
my advisers and co-authors Kathy and

9
00:00:32,560 --> 00:00:30,619
Mickey or spectral experts and Caryn and

10
00:00:34,090 --> 00:00:32,570
Tom are in the field with us and of

11
00:00:36,760 --> 00:00:34,100
course funding from NASA and the

12
00:00:38,790 --> 00:00:36,770
department can use this so the

13
00:00:41,950 --> 00:00:38,800

motivation for this work is really

14
00:00:43,630 --> 00:00:41,960
surrounding the sulfates on Mars as many

15
00:00:46,780 --> 00:00:43,640
of you may know if you follow the

16
00:00:48,430 --> 00:00:46,790
rover's and/or the orbiters a number of

17
00:00:50,709 --> 00:00:48,440
sulfates have been observed on Mars

18
00:00:53,620 --> 00:00:50,719
including gypsum and keys right which

19
00:00:56,500 --> 00:00:53,630
are calcium and magnesium sulfate

20
00:00:57,990 --> 00:00:56,510
respectively poly hydrated sulfates are

21
00:01:00,340 --> 00:00:58,000
a little bit harder to identify

22
00:01:03,400 --> 00:01:00,350
specifically because of their spectral

23
00:01:08,560 --> 00:01:03,410
signature and jerra site is the big one

24
00:01:12,310 --> 00:01:08,570
that prompted ideas about this acidic

25
00:01:14,620 --> 00:01:12,320
informations so the general term that I

26
00:01:16,240 --> 00:01:14,630
study or the general formation mechanism

27
00:01:17,440 --> 00:01:16,250
is acid sulphate weathering but that can

28
00:01:20,859 --> 00:01:17,450
hurt happen in a number of ways

29
00:01:22,780 --> 00:01:20,869
including briny evaporating lakes and

30
00:01:26,170 --> 00:01:22,790
volcanoes and a number of other ways

31
00:01:27,820 --> 00:01:26,180
dirty-ice impacts so I'm going to focus

32
00:01:31,380 --> 00:01:27,830
on the volcanic hydrothermal alteration

33
00:01:33,609 --> 00:01:31,390
and see if we can identify on earth

34
00:01:36,010 --> 00:01:33,619
diagnostic features that if we then

35
00:01:40,149 --> 00:01:36,020
observed on Mars could inform us about

36
00:01:42,940 --> 00:01:40,159
the Paleo conditions so we do this using

37
00:01:44,590 --> 00:01:42,950
fieldwork models and experiments today

38
00:01:48,010 --> 00:01:44,600

I'm going to talk about the field work

39
00:01:53,950 --> 00:01:48,020
and for scale this little light dot is a

40
00:01:55,780 --> 00:01:53,960
person and specifically the August 2012

41
00:01:58,090 --> 00:01:55,790
field work which was the first time we

42
00:02:00,039 --> 00:01:58,100
focused on insta to studies previously

43
00:02:02,590 --> 00:02:00,049
there had been about five campaigns down

44
00:02:06,280 --> 00:02:02,600
to Nicaragua but it was all sample and

45
00:02:09,279 --> 00:02:06,290
return so we took down Terra which is an

46
00:02:12,819 --> 00:02:09,289
portable x-ray of xrd which is

47
00:02:15,280 --> 00:02:12,829
comparable to chemin on MSL and then we

48
00:02:16,780 --> 00:02:15,290
also took down Terra spec 4 which is a

49
00:02:19,210 --> 00:02:16,790
portable visible near-infrared

50
00:02:22,030 --> 00:02:19,220
spectrometer which is a

51
00:02:24,520 --> 00:02:22,040
rivlin but has a higher resolution to

52
00:02:26,560 --> 00:02:24,530
the orbiting spectrometers we also took

53
00:02:29,320 --> 00:02:26,570
biological samples and then in our

54
00:02:34,360 --> 00:02:29,330
makeshift hotel laboratory prepared them

55
00:02:36,460 --> 00:02:34,370
to go through customs so in Nicaragua

56
00:02:38,500 --> 00:02:36,470
just to give you some context you have

57
00:02:40,420 --> 00:02:38,510
the Coco's plates abducting under the

58
00:02:41,920 --> 00:02:40,430
Caribbean plate and we're focusing on

59
00:02:44,950 --> 00:02:41,930
the volcanoes right here in Nicaragua

60
00:02:47,980 --> 00:02:44,960
our main one is Sarah Negro but we also

61
00:02:49,930 --> 00:02:47,990
have visited Momo tumbo talika and then

62
00:02:54,460 --> 00:02:49,940
the mud pots that are on this flank of

63
00:02:57,280 --> 00:02:54,470

talika as Mike mentioned earlier Sarah

64
00:02:59,860 --> 00:02:57,290
Negro is our youngest volcano it has a

65
00:03:02,020 --> 00:02:59,870
well-documented history a farmer salt

66
00:03:04,030 --> 00:03:02,030
popping up in his field one year and

67
00:03:06,449 --> 00:03:04,040
ever since then people have been

68
00:03:09,580 --> 00:03:06,459
observing it it most recently erupted in

69
00:03:12,360 --> 00:03:09,590
1999 although it's overdue for an

70
00:03:14,710 --> 00:03:12,370
eruption it erupts a belt every 10 years

71
00:03:18,640 --> 00:03:14,720
moma tone bone talika are much older

72
00:03:22,360 --> 00:03:18,650
volcanoes and have varied or varied

73
00:03:24,160 --> 00:03:22,370
activity and generally because these

74
00:03:27,220 --> 00:03:24,170
volcanoes are close to each other they

75
00:03:32,979 --> 00:03:27,230
have similar basalt chemistry's in the

76
00:03:35,229 --> 00:03:32,989
basaltic basaltic andesite so the reason

77
00:03:37,150 --> 00:03:35,239
we like these as an analog is because of

78
00:03:41,199 --> 00:03:37,160
that real-time observation but also

79
00:03:44,020 --> 00:03:41,209
because the bed the basalt at Nicaragua

80
00:03:46,780 --> 00:03:44,030
closely matches that of Mars so in this

81
00:03:49,120 --> 00:03:46,790
plot the black line is the average

82
00:03:51,729 --> 00:03:49,130
Theron Edgar basalt the red lines are

83
00:03:54,250 --> 00:03:51,739
the Martian material some are the

84
00:03:56,460 --> 00:03:54,260
bedrocks and some are meteorites you'll

85
00:03:59,470 --> 00:03:56,470
notice that the two big differences are

86
00:04:01,090 --> 00:03:59,480
iron is a little bit lower and aluminum

87
00:04:03,300 --> 00:04:01,100
is a little bit higher so we do have to

88
00:04:07,030 --> 00:04:03,310

take those into account when we're

89
00:04:08,229 --> 00:04:07,040
interpreting our observations so now I'm

90
00:04:10,270 --> 00:04:08,239
going to look at each of those four

91
00:04:13,900 --> 00:04:10,280
sites i mentioned and just show you some

92
00:04:16,120 --> 00:04:13,910
of the spectra that we found so this is

93
00:04:19,840 --> 00:04:16,130
an overview of Cerro Negro you hike up

94
00:04:21,340 --> 00:04:19,850
the outside wall here and if you like to

95
00:04:23,670 --> 00:04:21,350
live dangerously you can climb to the

96
00:04:25,719 --> 00:04:23,680
top and cinder board down the outside

97
00:04:29,260 --> 00:04:25,729
but then you're picking glass out of

98
00:04:31,659 --> 00:04:29,270
your arm if you fall and you walk around

99
00:04:32,950 --> 00:04:31,669
here and these are people for scale and

100
00:04:36,219 --> 00:04:32,960
then you can see that this

101
00:04:38,650 --> 00:04:36,229
entire wall here is what very is

102
00:04:41,439 --> 00:04:38,660
extremely altered and this is the 1992

103
00:04:43,330 --> 00:04:41,449
eruption wall so you have extensive

104
00:04:45,370 --> 00:04:43,340
alteration and not that much time this

105
00:04:47,350 --> 00:04:45,380
area right here which you can kind of

106
00:04:49,360 --> 00:04:47,360
see in this picture we call monkey face

107
00:04:51,339 --> 00:04:49,370
because it looks like a monkey and

108
00:04:54,879 --> 00:04:51,349
there's a lot of the biological studies

109
00:04:59,350 --> 00:04:54,889
go on there Sara Negro has anywhere from

110
00:05:01,809 --> 00:04:59,360
negative 1 ph to more I'll say neutral

111
00:05:05,499 --> 00:05:01,819
but still acidic for pH and ranges from

112
00:05:08,129 --> 00:05:05,509
ambient temperatures up to 150 degrees

113
00:05:10,629 --> 00:05:08,139

in the steam or just below the surface

114
00:05:14,230 --> 00:05:10,639
so some of the spectra that we typically

115
00:05:16,960 --> 00:05:14,240
find there are gypsum and silica this

116
00:05:19,540 --> 00:05:16,970
top plot is gypsum and for reference all

117
00:05:21,580 --> 00:05:19,550
the black spectra are filled spectra and

118
00:05:23,890 --> 00:05:21,590
all of the colored are the library

119
00:05:26,580 --> 00:05:23,900
spectra so you can see in this top

120
00:05:29,560 --> 00:05:26,590
example that we basically found

121
00:05:31,809 --> 00:05:29,570
laboratory library quality spectra of

122
00:05:33,520 --> 00:05:31,819
gypsum and we found this at Monkeyface

123
00:05:35,860 --> 00:05:33,530
this is a close-up picture of monkey

124
00:05:38,350 --> 00:05:35,870
face and a lot basically all of this

125
00:05:39,909 --> 00:05:38,360
white stuff is either gypsum or silica

126
00:05:42,149 --> 00:05:39,919
unfortunately you can't distinguish

127
00:05:45,010 --> 00:05:42,159
between the two just by looking at them

128
00:05:46,960 --> 00:05:45,020
and then we also have an evaporating out

129
00:05:48,999 --> 00:05:46,970
wash basin which we found to be

130
00:05:50,469 --> 00:05:49,009
important because priam previous

131
00:05:51,939 --> 00:05:50,479
campaigns we were always missing the

132
00:05:55,510 --> 00:05:51,949
magnesium sulfate which is a very

133
00:05:57,279 --> 00:05:55,520
soluble sulfate and the rocks are

134
00:06:00,339 --> 00:05:57,289
magnesium rich but we weren't finding

135
00:06:02,980 --> 00:06:00,349
any magnesium alteration minerals we

136
00:06:09,339 --> 00:06:02,990
ended up finding them using the spectra

137
00:06:11,800 --> 00:06:09,349
in this out wash basin momo tambo is the

138
00:06:14,560 --> 00:06:11,810

hardest field site to access it's a four

139
00:06:16,719 --> 00:06:14,570
and a half hour climb up here our cars

140
00:06:19,540 --> 00:06:16,729
are out over here and you climb up this

141
00:06:21,730 --> 00:06:19,550
old lava outflow channel it's also the

142
00:06:23,320 --> 00:06:21,740
hottest and most acidic environment

143
00:06:27,899 --> 00:06:23,330
there were temperatures well over 500

144
00:06:31,830 --> 00:06:27,909
degrees c and ph is down at negative 1

145
00:06:34,689 --> 00:06:31,840
so this site is dominated by sulfur and

146
00:06:37,330 --> 00:06:34,699
silica really what was interesting was

147
00:06:40,290 --> 00:06:37,340
even what we picked up as a yellow

148
00:06:42,820 --> 00:06:40,300
crystal we all assumed to be pure sulfur

149
00:06:44,800 --> 00:06:42,830
actually had a lot of hydration despite

150
00:06:46,780 --> 00:06:44,810
the high temperature from just as a

151
00:06:49,540 --> 00:06:46,790
surface water and then

152
00:06:51,580 --> 00:06:49,550
we also started seeing clays here so

153
00:06:54,550 --> 00:06:51,590
clays all right sorry Clay's are

154
00:06:58,230 --> 00:06:54,560
identified generally by either 2.2 or

155
00:07:03,990 --> 00:06:58,240
2.3 depending on what metal is in there

156
00:07:07,780 --> 00:07:04,000
and of course a hematite so talika is a

157
00:07:10,540 --> 00:07:07,790
volcano that we can't access the most

158
00:07:13,360 --> 00:07:10,550
active part basically when you get up to

159
00:07:17,320 --> 00:07:13,370
this rim it's a 500 meter drop straight

160
00:07:20,260 --> 00:07:17,330
down and our studies were restricted to

161
00:07:23,230 --> 00:07:20,270
these rim alterations as well as some of

162
00:07:25,240 --> 00:07:23,240
the free boulders interestingly when we

163
00:07:26,980 --> 00:07:25,250

went there it sounded like you were

164
00:07:29,050 --> 00:07:26,990
standing next to a jet engine I thought

165
00:07:31,150 --> 00:07:29,060
that was totally normal when we got off

166
00:07:32,800 --> 00:07:31,160
the volcano my advisor said no it

167
00:07:36,310 --> 00:07:32,810
normally doesn't make that noise and he

168
00:07:38,050 --> 00:07:36,320
was actually quite nervous fortunate it

169
00:07:42,640 --> 00:07:38,060
did erupted actually like a couple

170
00:07:44,050 --> 00:07:42,650
months after we left but so so it's

171
00:07:45,460 --> 00:07:44,060
leaked it even though we don't have a

172
00:07:47,320 --> 00:07:45,470
lot of mineral diversity because we

173
00:07:49,810 --> 00:07:47,330
can't access the most hydrothermally

174
00:07:52,270 --> 00:07:49,820
active areas did have the most ala night

175
00:07:53,950 --> 00:07:52,280
and Jerris site and jerra site is one of

176
00:07:57,070 --> 00:07:53,960
those minerals that was found on Mars

177
00:07:59,140 --> 00:07:57,080
it's an iron three-plus mineral and

178
00:08:00,700 --> 00:07:59,150
allen night has the same structure but

179
00:08:02,980 --> 00:08:00,710
there's aluminum in place of the iron

180
00:08:06,010 --> 00:08:02,990
what's interesting is that in the

181
00:08:09,640 --> 00:08:06,020
chemical studies we did gerrae site is

182
00:08:13,330 --> 00:08:09,650
actually rather rare and what we see is

183
00:08:16,840 --> 00:08:13,340
an iron-rich ala night and specifically

184
00:08:18,550 --> 00:08:16,850
a natural innate and Tom Macomb who was

185
00:08:21,610 --> 00:08:18,560
one of the collaborators in the field

186
00:08:24,700 --> 00:08:21,620
just put out a paper that looked at the

187
00:08:26,710 --> 00:08:24,710
spectral comparison of the different end

188
00:08:28,930 --> 00:08:26,720

members of the jera site ala night

189
00:08:31,800 --> 00:08:28,940
mineral groups and found that as you add

190
00:08:34,960 --> 00:08:31,810
more iron to an ala night the aluminum

191
00:08:38,560 --> 00:08:34,970
mineral you actually transform it into a

192
00:08:41,290 --> 00:08:38,570
jar site signature so this might add

193
00:08:44,220 --> 00:08:41,300
some uncertainty and the observations

194
00:08:48,760 --> 00:08:44,230
that we see on Mars with the mossbauer

195
00:08:52,600 --> 00:08:48,770
okay so the last site we looked at is

196
00:08:56,380 --> 00:08:52,610
San Jacinto mud pots and this area is an

197
00:08:59,110 --> 00:08:56,390
old they're open sorry there's lots of

198
00:09:00,120 --> 00:08:59,120
basically subsurface water and local

199
00:09:03,180 --> 00:09:00,130
children will keep you

200
00:09:04,860 --> 00:09:03,190
from stepping into a boiling pot and

201
00:09:08,250 --> 00:09:04,870
there's a lot it's a much higher fluid

202
00:09:09,990 --> 00:09:08,260
Iraq ratio so you end up finding more of

203
00:09:14,130 --> 00:09:10,000
the clays so there's montmorillonite

204
00:09:15,390 --> 00:09:14,140
here which is an aluminum clay and i

205
00:09:17,220 --> 00:09:15,400
don't think i have an example if you're

206
00:09:18,780 --> 00:09:17,230
out here it is this one which is

207
00:09:22,620 --> 00:09:18,790
actually not marked is a two point three

208
00:09:24,720 --> 00:09:22,630
which is indicative of iron magnesium so

209
00:09:28,500 --> 00:09:24,730
just going to kind of show you this this

210
00:09:30,780 --> 00:09:28,510
is the xrd and this is the spectra we

211
00:09:32,730 --> 00:09:30,790
use them in conjunction I obviously only

212
00:09:33,660 --> 00:09:32,740
spoke about the spectra here today

213
00:09:36,150 --> 00:09:33,670

because they each have their own

214
00:09:38,160 --> 00:09:36,160
strengths and combining this story oh

215
00:09:40,230 --> 00:09:38,170
sorry i'll jump ahead combining the

216
00:09:42,780 --> 00:09:40,240
story we can kind of create a table of

217
00:09:45,120 --> 00:09:42,790
abundances and we determine that the

218
00:09:47,070 --> 00:09:45,130
primary controls are the actual

219
00:09:49,770 --> 00:09:47,080
composition of the gas in the rock and

220
00:09:52,350 --> 00:09:49,780
then secondary controls of alteration

221
00:09:55,260 --> 00:09:52,360
are the ph the fluid direct ratio and

222
00:09:58,740 --> 00:09:55,270
there are basically five categories that

223
00:10:00,780 --> 00:09:58,750
we classify here the hottest highest

224
00:10:04,080 --> 00:10:00,790
temperature environments you have

225
00:10:06,810 --> 00:10:04,090
elemental sulfur and amorphous silica at

226
00:10:08,880 --> 00:10:06,820
more moderate vents you have you start

227
00:10:11,610 --> 00:10:08,890
forming more more gypsum and other

228
00:10:13,560 --> 00:10:11,620
sulfates as well as the iron oxides and

229
00:10:16,350 --> 00:10:13,570
then all of your and then many of your

230
00:10:19,230 --> 00:10:16,360
hydrated sulfates start coming in in

231
00:10:20,490 --> 00:10:19,240
these washout areas and I just want to

232
00:10:24,150 --> 00:10:20,500
jump back to the biology because I

233
00:10:27,060 --> 00:10:24,160
skipped over it we find biology at Cerro

234
00:10:29,250 --> 00:10:27,070
Negro in particular or the best examples

235
00:10:31,530 --> 00:10:29,260
we find are at monkey cheek it's the

236
00:10:33,510 --> 00:10:31,540
characteristic red rock green

237
00:10:35,610 --> 00:10:33,520
photosynthetic layer and then the white

238
00:10:38,430 --> 00:10:35,620

center in this case the white center is

239
00:10:41,340 --> 00:10:38,440
actually silica and not gypsum and

240
00:10:44,250 --> 00:10:41,350
looking at that an SEM you have these

241
00:10:45,930 --> 00:10:44,260
fuels which are very carbon-rich and

242
00:10:48,750 --> 00:10:45,940
sometimes we find that they're encased

243
00:10:51,630 --> 00:10:48,760
in silica as a possible bio preservation

244
00:10:53,160 --> 00:10:51,640
and not in this example but in other

245
00:10:57,480 --> 00:10:53,170
ones you can actually see collapse

246
00:10:59,820 --> 00:10:57,490
murals and for those of you who know

247
00:11:02,550 --> 00:10:59,830
biology you can understand those names

248
00:11:04,980 --> 00:11:02,560
this is all work that Karen joe rogers

249
00:11:06,750 --> 00:11:04,990
does and so i don't know and then i'll

250
00:11:09,240 --> 00:11:06,760
just briefly make some connections to

251
00:11:11,579 --> 00:11:09,250
Mars if anyone works with Omega or prism

252
00:11:13,900 --> 00:11:11,589
data it can be much harder than field

253
00:11:15,640 --> 00:11:13,910
data most of our field site

254
00:11:17,530 --> 00:11:15,650
are dominated by silica so we would

255
00:11:20,680 --> 00:11:17,540
anticipate that they look more like this

256
00:11:22,930 --> 00:11:20,690
serious major identified by a broad hump

257
00:11:25,870 --> 00:11:22,940
here and then the interesting thing with

258
00:11:28,570 --> 00:11:25,880
detailed mineralogical spectra are the

259
00:11:30,940 --> 00:11:28,580
reverse of the global sequence which

260
00:11:33,760 --> 00:11:30,950
people have kind of said there are

261
00:11:35,650 --> 00:11:33,770
global or local differences and we say

262
00:11:39,100 --> 00:11:35,660
well we see all of these minerals in a

263
00:11:40,830 --> 00:11:39,110

volcanic environment so perhaps some of

264
00:11:44,290 --> 00:11:40,840
these areas can be explained that way

265
00:11:46,180 --> 00:11:44,300
and then jera site again maybe a

266
00:11:48,460 --> 00:11:46,190
localized vent especially due to its

267
00:11:51,400 --> 00:11:48,470
morphology the jarosite is this orange

268
00:11:52,810 --> 00:11:51,410
piece here and I'll leave these up and

269
00:12:03,250 --> 00:11:52,820
we can take questions before everyone

270
00:12:15,130 --> 00:12:03,260
rushes to coffee I think coffee is more

271
00:12:17,500 --> 00:12:15,140
of an attraction no oh he knows no no I

272
00:12:19,600 --> 00:12:17,510
mean I think waters I'm certainly

273
00:12:21,430 --> 00:12:19,610
there's strong strong evidence of water

274
00:12:23,590 --> 00:12:21,440
and I think that the fact that you have

275
00:12:25,750 --> 00:12:23,600
water and you have persistent water

276
00:12:29,410 --> 00:12:25,760
based on the valley networks and deltas

277
00:12:33,670 --> 00:12:29,420
and persistent vault volcanism which has

278
00:12:35,230 --> 00:12:33,680
a new paper with a kind of a co-worker I

279
00:12:38,530 --> 00:12:35,240
guess another student of my advisors

280
00:12:41,050 --> 00:12:38,540
showed that fault that volcanism ended

281
00:12:43,600 --> 00:12:41,060
as early as a few million years ago I

282
00:12:46,540 --> 00:12:43,610
think you combining those two you get a

283
00:12:49,150 --> 00:12:46,550
aqueous alteration in a volcanic

284
00:12:51,400 --> 00:12:49,160
environment but certainly you have lots