

Natsumi Noda

*Groundwater Upwelling & Redox-based
Habitability within Gale Crater Lake
on Early Mars*

1
00:00:00,240 --> 00:00:12,480

[Music]

2
00:00:21,400 --> 00:00:17,050

and I'm PhD student of off sorry about

3
00:00:24,159 --> 00:00:21,410

it and again my environment it interest

4
00:00:26,650 --> 00:00:24,169

is so what is life and what is habitable

5
00:00:28,900 --> 00:00:26,660

so I'm really happy to be part of this

6
00:00:31,120 --> 00:00:28,910

station and today I would like to talk

7
00:00:35,050 --> 00:00:31,130

about my mass transit project about

8
00:00:40,900 --> 00:00:35,060

reconstructing because environment and

9
00:00:43,600 --> 00:00:40,910

also habitability on Earth and Mars much

10
00:00:46,930 --> 00:00:43,610

more line of yamaraja go and geochemical

11
00:00:49,870 --> 00:00:46,940

everything support evidences of awakened

12
00:00:52,900 --> 00:00:49,880

water on array mouth although the amount

13
00:00:57,940 --> 00:00:52,910

of amount of water or climate at the

14

00:01:00,270 --> 00:00:57,950

time is still under debate stage further

15

00:01:04,240 --> 00:01:00,280

have the beauty on saturn

16

00:01:06,640 --> 00:01:04,250

environment on planetary surface above

17

00:01:09,870 --> 00:01:06,650

and assessing availability of oxidant

18

00:01:12,670 --> 00:01:09,880

and reductant is essential because

19

00:01:17,770 --> 00:01:12,680

catabolic energy could be available from

20

00:01:20,500 --> 00:01:17,780

the redox reaction from the cidade and

21

00:01:26,500 --> 00:01:20,510

chemically reacting in the equilibrium

22

00:01:29,710 --> 00:01:26,510

state on earth math for the possibility

23

00:01:33,910 --> 00:01:29,720

of a highly oxidizing environment is

24

00:01:36,940 --> 00:01:33,920

proposed by my previous study so if you

25

00:01:39,850 --> 00:01:36,950

interested in this topic please tell me

26

00:01:43,660 --> 00:01:39,860

after but in this talk I'd like to focus

27

00:01:47,410 --> 00:01:43,670

on supply of reductant reductant such as

28

00:01:50,289 --> 00:01:47,420

iron or hydrogen could have supplied

29

00:01:52,510 --> 00:01:50,299

from subsurface through water Rock

30

00:01:56,260 --> 00:01:52,520

reaction dissolved by motoric reaction

31

00:01:59,640 --> 00:01:56,270

to reaction and then supplied by

32

00:02:02,230 --> 00:01:59,650

upwelling of groundwater in

33

00:02:05,350 --> 00:02:02,240

understanding the input flux of this

34

00:02:07,750 --> 00:02:05,360

component we can further predict the

35

00:02:11,780 --> 00:02:07,760

ecosystem and biomass the sustainable in

36

00:02:19,350 --> 00:02:14,310

NASA's Curiosity rover which is ongoing

37

00:02:24,630 --> 00:02:19,360

mission Mars have reported key

38

00:02:28,170 --> 00:02:24,640

information do to quantify the supply of

39

00:02:31,890 --> 00:02:28,180

reductant it was a lake environment on

40

00:02:36,270 --> 00:02:31,900

further Mars the Houston rover landed on

41

00:02:39,060 --> 00:02:36,280

the calculator and observed Menaka and

42

00:02:43,560 --> 00:02:39,070

chemical composition of sedimentary

43

00:02:48,780 --> 00:02:43,570

month which is deposit when the lake

44

00:02:51,540 --> 00:02:48,790

filled this crater and it was reported

45

00:02:54,600 --> 00:02:51,550

that muscle layer of reformation is

46

00:02:58,430 --> 00:02:54,610

characterized by enrichment of silica

47

00:03:01,770 --> 00:02:58,440

and iron oxide which is seem to be

48

00:03:05,430 --> 00:03:01,780

pretty precipitated and deposited within

49

00:03:08,190 --> 00:03:05,440

the lake so this support dissolved iron

50

00:03:10,010 --> 00:03:08,200

and nickel would have delivered by up

51

00:03:13,080 --> 00:03:10,020

wearing ground water in public

52

00:03:18,270 --> 00:03:13,090

environment and especially interest Erin

53

00:03:21,660 --> 00:03:18,280

could have acted as reductant however

54

00:03:24,480 --> 00:03:21,670

the contribution of ground water into

55

00:03:28,680 --> 00:03:24,490

the Gila leg and their sediment is a Hal

56

00:03:33,720 --> 00:03:28,690

not been investigated well so I tried in

57

00:03:36,930 --> 00:03:33,730

my study I tried to other this by the

58

00:03:38,880 --> 00:03:36,940

body into question the first question if

59

00:03:42,390 --> 00:03:38,890

that groundwater could have upward

60

00:03:44,150 --> 00:03:42,400

filling the oracles a crater lake and to

61

00:03:45,990 --> 00:03:44,160

answer this question I use

62

00:03:50,460 --> 00:03:46,000

three-dimensional hydrological

63

00:03:52,530 --> 00:03:50,470

simulation to contain about which

64

00:03:54,840 --> 00:03:52,540

environment

65

00:03:59,330 --> 00:03:54,850

does capable of operating grant water

66

00:04:02,370 --> 00:03:59,340

and explain the distribution of Lake and

67

00:04:04,470 --> 00:04:02,380

then the second question is how much

68

00:04:08,070 --> 00:04:04,480

thicker interest Erin could be contained

69

00:04:11,010 --> 00:04:08,080

many for this all in grant water it'll

70

00:04:13,110 --> 00:04:11,020

reveal this I conducted lowered

71

00:04:16,890 --> 00:04:13,120

experiment to simulate a water rock

72

00:04:18,280 --> 00:04:16,900

reaction a subcircuit immersion Mars

73

00:04:23,110 --> 00:04:18,290

surface a must

74

00:04:26,590 --> 00:04:23,120

subsurface understand the determining

75

00:04:28,570 --> 00:04:26,600

factor of his eleven of silicon iron and

76

00:04:31,570 --> 00:04:28,580

combine in most of the result I

77

00:04:34,270 --> 00:04:31,580

estimated the input clock of nickel and

78

00:04:36,100 --> 00:04:34,280

iron and compare with observation to

79

00:04:42,520 --> 00:04:36,110

assess the rate of space available

80

00:04:46,390 --> 00:04:42,530

energy three-dimensional hydrological

81

00:04:52,930 --> 00:04:46,400

simulation on the margin surf motion

82

00:04:55,450 --> 00:04:52,940

under Mars by using model the originally

83

00:04:56,910 --> 00:04:55,460

developer to do civil engineering by

84

00:05:01,320 --> 00:04:56,920

changing the gravitational acceleration

85

00:05:05,920 --> 00:05:01,330

in this model we can saw steady state of

86

00:05:09,070 --> 00:05:05,930

water distribution and flow under giving

87

00:05:12,820 --> 00:05:09,080

topography geology and climate condition

88

00:05:17,080 --> 00:05:12,830

many based on mass conservation law and

89

00:05:19,660 --> 00:05:17,090

the zero net loss is a low ground water

90

00:05:22,240 --> 00:05:19,670

flow and the groundwater flows in

91

00:05:26,770 --> 00:05:22,250

proportion to the aggregation of

92

00:05:31,270 --> 00:05:26,780

pressures and to investigate the lake

93

00:05:35,500 --> 00:05:31,280

distribution and put this on and wrote a

94

00:05:37,900 --> 00:05:35,510

talk up wedding we calculated the area

95

00:05:40,750 --> 00:05:37,910

surrounding air cleaners as shown here

96

00:05:44,020 --> 00:05:40,760

and under different operation rate and

97

00:05:48,100 --> 00:05:44,030

hydraulic head harder egghead is the

98

00:05:52,450 --> 00:05:48,110

water level under southbounder surface

99

00:05:55,450 --> 00:05:52,460

at subsurface so zero means the motor

100

00:05:58,060 --> 00:05:55,460

rated a surface and one means that the

101
00:06:04,060 --> 00:05:58,070
that is a lot of water level is lower

102
00:06:07,600 --> 00:06:04,070
which mean the water amount is small the

103
00:06:09,690 --> 00:06:07,610
operation that is correspond to climate

104
00:06:12,550 --> 00:06:09,700
aridity

105
00:06:16,450 --> 00:06:12,560
also we calculated the for time for also

106
00:06:22,000 --> 00:06:16,460
16 types of 16 condition but I will show

107
00:06:24,880 --> 00:06:22,010
the typical three types of wizard under

108
00:06:26,440 --> 00:06:24,890
different operation rate and different

109
00:06:29,800 --> 00:06:26,450
hydraulic head

110
00:06:32,020 --> 00:06:29,810
in this period the left-hand side

111
00:06:34,480 --> 00:06:32,030
figures show the surface water

112
00:06:36,910 --> 00:06:34,490
distribution and the right-hand final

113
00:06:39,880 --> 00:06:36,920

figures show the north-south cross

114

00:06:47,980 --> 00:06:39,890

section and this line is a streamlined

115

00:06:53,500 --> 00:06:47,990

Zoda is so the Mayo so this means a

116

00:06:56,560 --> 00:06:53,510

water flow like this okay and we found

117

00:07:01,180 --> 00:06:56,570

that there is a term mode or two still

118

00:07:03,580 --> 00:07:01,190

mode of tartar to model through ground

119

00:07:05,800 --> 00:07:03,590

water from gradually depend on

120

00:07:12,850 --> 00:07:05,810

evaporation rate rather than hydraulic

121

00:07:17,440 --> 00:07:12,860

head in no operation Lake mode or wet

122

00:07:20,640 --> 00:07:17,450

condition an eviction from south to

123

00:07:24,280 --> 00:07:20,650

north that follows the topographic

124

00:07:27,970 --> 00:07:24,290

topography is a main stream whereas

125

00:07:32,050 --> 00:07:27,980

under high evaporation rate which means

126
00:07:34,360 --> 00:07:32,060
arid conditions groundwater upgrade from

127
00:07:38,770 --> 00:07:34,370
operating random of groundwater occur

128
00:07:45,660 --> 00:07:38,780
and multiple leak appears learning

129
00:07:49,540 --> 00:07:45,670
calculator and we also found that this

130
00:07:51,430 --> 00:07:49,550
operating triggered under evaporation

131
00:07:57,850 --> 00:07:51,440
our highest point one to one millimeter

132
00:08:01,240 --> 00:07:57,860
per day compared to observation it was

133
00:08:03,820 --> 00:08:01,250
reported the leg is the luxury sediment

134
00:08:07,960 --> 00:08:03,830
is found not only inside the calculator

135
00:08:11,500 --> 00:08:07,970
but also a sum of 13 crater and this is

136
00:08:13,330 --> 00:08:11,510
well explained by operating mode rather

137
00:08:18,130 --> 00:08:13,340
than advection mode

138
00:08:20,980 --> 00:08:18,140

so our readers support arid climate and

139

00:08:25,030 --> 00:08:20,990

shallow water table at the time we'll

140

00:08:31,720 --> 00:08:25,040

look at the water and existed on Mars in

141

00:08:37,360 --> 00:08:35,020

come from five or ten kilometer beneath

142

00:08:40,960 --> 00:08:37,370

the surface where temperature is of

143

00:08:47,170 --> 00:08:40,970

highest hundred degree considering the

144

00:08:49,930 --> 00:08:47,180

temperature gradient at that time so to

145

00:08:55,150 --> 00:08:49,940

understand estimated composition of

146

00:08:58,020 --> 00:08:55,160

groundwater we use the word experiment

147

00:09:04,060 --> 00:08:58,030

to simulate the hydrothermal thread and

148

00:09:07,300 --> 00:09:04,070

what Rock reaction starting material

149

00:09:08,980 --> 00:09:07,310

seems like grass which okay of its

150

00:09:12,040 --> 00:09:08,990

chemical composition follow the

151
00:09:22,030 --> 00:09:12,050
conglomerate that oh that of measured by

152
00:09:25,870 --> 00:09:22,040
curiosity class and crash grain like

153
00:09:28,300 --> 00:09:25,880
this including the reaction vessels of

154
00:09:30,670 --> 00:09:28,310
made with made by coal pure gold

155
00:09:34,330 --> 00:09:30,680
together with pure water and carbon

156
00:09:38,620 --> 00:09:34,340
dioxide gas and pressurised by water and

157
00:09:41,650 --> 00:09:38,630
heated to assimilate high temperature

158
00:09:44,890 --> 00:09:41,660
and high pressure cool condition and

159
00:09:45,810 --> 00:09:44,900
Martian subsurface and kept for more

160
00:09:51,070 --> 00:09:45,820
than two months

161
00:09:58,960 --> 00:09:55,210
the chemistry of the lake example

162
00:10:02,590 --> 00:09:58,970
created during the experiment and I know

163
00:10:08,050 --> 00:10:02,600

that the mineralogy of the remain solid

164

00:10:11,290 --> 00:10:08,060

sample and here is a research and this

165

00:10:14,890 --> 00:10:11,300

figure shows the time variation of ion

166

00:10:18,030 --> 00:10:14,900

and concentration ion and camera dioxide

167

00:10:23,590 --> 00:10:18,040

and also pH of the solution and we can

168

00:10:27,400 --> 00:10:23,600

you can see that the concentration of C

169

00:10:31,630 --> 00:10:27,410

created almost table which means the

170

00:10:33,070 --> 00:10:31,640

reason the concentration controlled by

171

00:10:35,770 --> 00:10:33,080

the dollar store equilibrium with

172

00:10:38,500 --> 00:10:35,780

precipitated secondary mineral and

173

00:10:40,750 --> 00:10:38,510

compared to the silica are the

174

00:10:41,450 --> 00:10:40,760

concentration iron is very low but this

175

00:10:48,290 --> 00:10:41,460

is not

176

00:10:51,380 --> 00:10:48,300

because other the alkaline solution iron

177

00:10:55,010 --> 00:10:51,390

and magnesium is stable in solid phase

178

00:10:58,730 --> 00:10:55,020

and this is consistent with the middle

179

00:11:02,829 --> 00:10:58,740

of observed minerals issuing here and we

180

00:11:06,710 --> 00:11:02,839

found the previous precipitation of

181

00:11:09,050 --> 00:11:06,720

Haran magnus still bearing clay minerals

182

00:11:11,690 --> 00:11:09,060

such as serpentine estoppel night and we

183

00:11:14,269 --> 00:11:11,700

can also found we also found the

184

00:11:16,430 --> 00:11:14,279

precipitation seeker is all silica rich

185

00:11:20,269 --> 00:11:16,440

material and also a trace amount of

186

00:11:25,810 --> 00:11:20,279

calcite and magnetite and to understand

187

00:11:39,079 --> 00:11:29,510

compare them major concentration with

188

00:11:43,490 --> 00:11:39,089

term thermodynamic internal energy

189

00:11:47,240 --> 00:11:43,500

predicted concentration assuming the

190

00:11:51,100 --> 00:11:47,250

direction equilibria always these form

191

00:11:53,090 --> 00:11:51,110

detected minerals and we found that the

192

00:11:55,550 --> 00:11:53,100

concentration of sneaker is well

193

00:12:01,010 --> 00:11:55,560

explained by the original equilibria

194

00:12:04,010 --> 00:12:01,020

with cold whereas that of iron is well

195

00:12:09,040 --> 00:12:04,020

explained only by the solution cable

196

00:12:11,050 --> 00:12:09,050

with cigarette or carbonate of iron

197

00:12:14,990 --> 00:12:11,060

surprisingly

198

00:12:19,130 --> 00:12:15,000

other observed minerals correspond to

199

00:12:21,440 --> 00:12:19,140

more lower much lower concentrations so

200

00:12:25,130 --> 00:12:21,450

this means that trace amount of silica

201

00:12:28,930 --> 00:12:25,140

control the concentration of article

202

00:12:35,260 --> 00:12:32,110

so I'm combining both of the reservists

203

00:12:41,490 --> 00:12:35,270

one model and experiment with the missus

204

00:12:44,020 --> 00:12:41,500

apply flux of silica and iron the

205

00:12:47,080 --> 00:12:44,030

operating rate of groundwater should

206

00:12:53,970 --> 00:12:47,090

have comparable to the evaporation rate

207

00:13:01,480 --> 00:12:59,020

concentration of sake guys like this and

208

00:13:04,030 --> 00:13:01,490

multiplying this we can estimate the

209

00:13:08,650 --> 00:13:04,040

flux of sneaker and also deposition rate

210

00:13:13,750 --> 00:13:08,660

assuming upcoming silica all about

211

00:13:20,220 --> 00:13:13,760

silica the precipitate I on the other

212

00:13:24,640 --> 00:13:20,230

hand here over reported the mud must on

213

00:13:29,260 --> 00:13:24,650

there possess the fine alum in astronomy

214

00:13:31,870 --> 00:13:29,270

Gnostic alumina lytic layer on which

215

00:13:35,770 --> 00:13:31,880

thickness is comparable to the

216

00:13:44,550 --> 00:13:35,780

deposition rate which means La Mina in

217

00:13:52,750 --> 00:13:47,860

we can also estimate the products of our

218

00:13:56,200 --> 00:13:52,760

own in the similar way and together with

219

00:14:02,910 --> 00:13:56,210

oxidizing environment the Gibbs free

220

00:14:06,490 --> 00:14:02,920

energy generated by generated by

221

00:14:09,520 --> 00:14:06,500

oxidation of iron to hematite can be

222

00:14:12,130 --> 00:14:09,530

calculated all highest 0.1 Joule per

223

00:14:14,230 --> 00:14:12,140

kilogram upward in groundwater and

224

00:14:17,460 --> 00:14:14,240

together with anabolic energy that

225

00:14:21,480 --> 00:14:17,470

estimated based on TV stereo and your

226

00:14:25,860 --> 00:14:21,490

microbiological study the biomass

227

00:14:30,940 --> 00:14:25,870

sustainable by this our own operating it

228

00:14:33,730 --> 00:14:30,950

estimated up the 0.1 gram per square

229

00:14:37,450 --> 00:14:33,740

meters per month year it this this

230

00:14:42,450 --> 00:14:37,460

amount is compared to the deposition

231

00:14:47,460 --> 00:14:42,460

rate around 100 ppm of Oregon

232

00:14:50,940 --> 00:14:47,470

it's detectable by your zero so to

233

00:14:58,890 --> 00:14:50,950

summarize to estimate the available

234

00:15:00,870 --> 00:14:58,900

energy based on observation if you

235

00:15:07,230 --> 00:15:00,880

conduct an hydrological simulation and

236

00:15:20,460 --> 00:15:07,240

water reactor experiment yeah thank you

237

00:15:22,410 --> 00:15:20,470

morning hi

238

00:15:24,390 --> 00:15:22,420

are you interested in kind of going

239

00:15:26,400 --> 00:15:24,400

another step further and sort of

240

00:15:27,900 --> 00:15:26,410

starting to see you how it's sulfur rich

241

00:15:29,670 --> 00:15:27,910

atmosphere might start interacting with

242

00:15:31,260 --> 00:15:29,680

the fluids you're predicting to generate

243

00:15:32,670 --> 00:15:31,270

a lot of the metastable sulfates like

244

00:15:34,680 --> 00:15:32,680

someone mentioned chair said earlier and

245

00:15:44,210 --> 00:15:34,690

those are the things that we see in

246

00:15:48,750 --> 00:15:44,220

calculator yes yes yeah I'm always

247

00:15:52,170 --> 00:15:48,760

interested in circles and I'm thinking

248

00:15:56,330 --> 00:15:52,180

of yeah surprise it also really reactive

249

00:16:01,620 --> 00:15:56,340

and so I'm thinking of estimating server

250

00:16:04,950 --> 00:16:01,630

flux in my mmm I think I can either in

251
00:16:12,900 --> 00:16:04,960
my PhD or my PhD studies topic yes thank

252
00:16:18,010 --> 00:16:16,120
yeah hey big you really can talk um in

253
00:16:20,800 --> 00:16:18,020
your experiment you had like it outflow

254
00:16:22,720 --> 00:16:20,810
tube so you could to the sample yes were

255
00:16:24,730 --> 00:16:22,730
you taking that water like everyday and

256
00:16:26,110 --> 00:16:24,740
was that reducing the amount of water in

257
00:16:28,060 --> 00:16:26,120
your experiment and you feel that cause

258
00:16:29,560 --> 00:16:28,070
then I don't know change the

259
00:16:40,150 --> 00:16:29,570
concentration of ions or anything like

260
00:16:45,210 --> 00:16:40,160
that my experiment yeah we get sample

261
00:16:48,550 --> 00:16:45,220
from online sample and so I measured

262
00:16:55,660 --> 00:16:48,560
about seven times okay yeah

263
00:16:57,850 --> 00:16:55,670

and so but mother something the amount

264

00:17:12,569 --> 00:16:57,860

of sample is very small so it's not

265

00:17:20,710 --> 00:17:17,260

hi there we go so just a quick question

266

00:17:24,159 --> 00:17:20,720

about your prevailing assumption of the

267

00:17:26,309 --> 00:17:24,169

availability of oxidants so in your

268

00:17:30,779 --> 00:17:26,319

schematic you kind of showed it as

269

00:17:33,519 --> 00:17:30,789

oxygen in the atmosphere yes and I

270

00:17:35,200 --> 00:17:33,529

assume that you're thinking that the

271

00:17:39,700 --> 00:17:35,210

oxygen is produced by some photolytic

272

00:17:45,399 --> 00:17:42,010

upper or lower limits on your assumption

273

00:17:48,700 --> 00:17:45,409

of what the atmospheric level of oxygen

274

00:17:57,549 --> 00:17:48,710

could have been in order to produce

275

00:18:00,430 --> 00:17:57,559

these reactions related by the kirov

276

00:18:04,870 --> 00:18:00,440

upon the manganese oxide in the filament

277

00:18:07,019 --> 00:18:04,880

so we think we are thinking also more

278

00:18:11,950 --> 00:18:07,029

than several maneuvers

279

00:18:14,230 --> 00:18:11,960

atmosphere should be in the Ottoman era

280

00:18:20,139 --> 00:18:14,240

to explain that funny

281

00:18:23,380 --> 00:18:20,149

Oh margulies oxide inga filament all