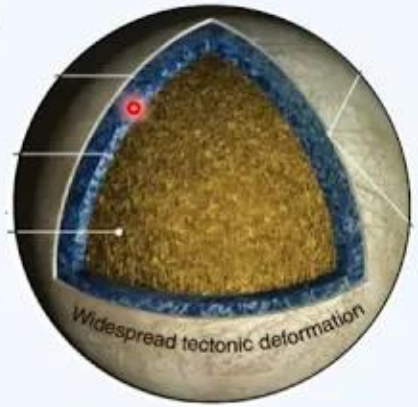
Satellites of Jupiter, Saturn,…

Ganymede

NASA/JPL-Caltech



Europa

Howell and Pappalardo, 2020

NASA/JPL-Caltech

Titan

Possibility to have a subsurface ocean

Importance of understanding the ocean

- Why are they so different?
- How are materials circulating?
- How have they evolved?
- Are they habitable worlds?

1
00:00:06,470 --> 00:00:03,110
hello i'm suns kenosaki

2
00:00:08,629 --> 00:00:06,480
a master student at lc tokyo tech

3
00:00:09,990 --> 00:00:08,639
it is a great honor to be able to speak

4
00:00:11,990 --> 00:00:10,000
to you today

5
00:00:13,509 --> 00:00:12,000
i'd like to thank the organizers for

6
00:00:17,109 --> 00:00:13,519
choosing my abstract

7
00:00:19,429 --> 00:00:17,119
for live streaming today i'll give you a

8
00:00:21,029 --> 00:00:19,439
presentation of the results of high

9
00:00:24,150 --> 00:00:21,039
pressure viscosity measurements

10
00:00:25,429 --> 00:00:24,160
of mgsl4 solutions which is one of the

11
00:00:27,589 --> 00:00:25,439
possible compositions

12
00:00:28,630 --> 00:00:27,599
of the subsurface ocean of isis

13
00:00:30,790 --> 00:00:28,640

satellites

14
00:00:31,750 --> 00:00:30,800
and some implications for these

15
00:00:34,790 --> 00:00:31,760
environments

16
00:00:38,470 --> 00:00:34,800
and habitability first

17
00:00:40,630 --> 00:00:38,480
i would like to introduce icy satellites

18
00:00:43,510 --> 00:00:40,640
ic satellites are the major type of

19
00:00:47,110 --> 00:00:43,520
satellites of outer solar system planets

20
00:00:49,750 --> 00:00:47,120
and composed mainly of ice and rocks

21
00:00:51,110 --> 00:00:49,760
with the research progress it has become

22
00:00:54,389 --> 00:00:51,120
highly probable that

23
00:00:58,150 --> 00:00:54,399
some big isis attracts such as ganymede

24
00:01:01,029 --> 00:00:58,160
europa and titan have an ocean

25
00:01:03,750 --> 00:01:01,039
of liquid water underneath the thick ice

26
00:01:06,149 --> 00:01:03,760
crust covering the surface

27
00:01:07,350 --> 00:01:06,159
understanding this ocean environment is

28
00:01:09,910 --> 00:01:07,360
an important topic

29
00:01:11,429 --> 00:01:09,920
because it can lead to discussions on

30
00:01:14,710 --> 00:01:11,439
the diversity

31
00:01:19,670 --> 00:01:14,720
material cycle evolution

32
00:01:24,630 --> 00:01:22,630
what is the ocean environment like this

33
00:01:27,190 --> 00:01:24,640
figure is the pressure and temperature

34
00:01:30,630 --> 00:01:27,200
phase diagram of pure water

35
00:01:32,469 --> 00:01:30,640
markers on the vertical axis indicates

36
00:01:35,270 --> 00:01:32,479
the pressure of the boundary

37
00:01:36,310 --> 00:01:35,280
between the hydrosphere hydrosphere and

38
00:01:40,069 --> 00:01:36,320

the rocky layer

39
00:01:44,149 --> 00:01:40,079
of each body earth europa

40
00:01:46,789 --> 00:01:44,159
titan and climate as you can see here

41
00:01:47,749 --> 00:01:46,799
the ocean on these icy satellites has a

42
00:01:51,350 --> 00:01:47,759
larger

43
00:01:53,590 --> 00:01:51,360
maximum pressure than the earth's ocean

44
00:01:55,030 --> 00:01:53,600
and reaches one giga pascal in some

45
00:01:57,109 --> 00:01:55,040
satellite

46
00:01:59,510 --> 00:01:57,119
the assumed pressure temperature

47
00:02:00,950 --> 00:01:59,520
condition inside the icy satellites are

48
00:02:04,469 --> 00:02:00,960
shaded in blue

49
00:02:06,469 --> 00:02:04,479
and conditions of the ocean are shaded

50
00:02:09,270 --> 00:02:06,479
in that

51
00:02:11,670 --> 00:02:09,280
it should be noted that the actual ocean

52
00:02:14,790 --> 00:02:11,680
contains a variety of salt

53
00:02:18,150 --> 00:02:14,800
which lower the melting point somewhat

54
00:02:20,790 --> 00:02:18,160
and broadened the condition of the ocean

55
00:02:21,589 --> 00:02:20,800
the composition of the ocean has been

56
00:02:24,630 --> 00:02:21,599
discussed

57
00:02:27,270 --> 00:02:24,640
from various viewpoints such as surface

58
00:02:31,030 --> 00:02:27,280
composition

59
00:02:32,710 --> 00:02:31,040
in this study we focus on mgso4

60
00:02:35,589 --> 00:02:32,720
magnesium sulfate

61
00:02:36,150 --> 00:02:35,599
as one of the possible compositions for

62
00:02:38,790 --> 00:02:36,160
more

63
00:02:40,869 --> 00:02:38,800

accurate view of the ocean environment

64
00:02:44,070 --> 00:02:40,879
it is essential to understand

65
00:02:44,790 --> 00:02:44,080
how the ocean fluid behaves and the low

66
00:02:48,790 --> 00:02:44,800
temperature

67
00:02:54,630 --> 00:02:51,589
here i will focus on viscosity as one of

68
00:02:56,550 --> 00:02:54,640
the essential properties of the fluid

69
00:02:58,149 --> 00:02:56,560
this property determines material

70
00:03:01,190 --> 00:02:58,159
transport by diffusion

71
00:03:04,149 --> 00:03:01,200
and how fluid moves viscosity

72
00:03:06,390 --> 00:03:04,159
is dependent on pressure temperature and

73
00:03:09,670 --> 00:03:06,400
composition

74
00:03:13,190 --> 00:03:09,680
the figure shows the change in viscosity

75
00:03:15,350 --> 00:03:13,200
by adding various salt to water

76
00:03:17,110 --> 00:03:15,360
where the horizontal axis is the

77
00:03:20,229 --> 00:03:17,120
concentration

78
00:03:21,030 --> 00:03:20,239
and the vertical axis is the relative

79
00:03:24,470 --> 00:03:21,040
viscosity

80
00:03:27,990 --> 00:03:24,480
to water in particular

81
00:03:31,509 --> 00:03:28,000
the effect of mgs cell 4 on viscosity

82
00:03:34,149 --> 00:03:31,519
is very large in other words

83
00:03:35,750 --> 00:03:34,159
if the subsurface ocean contains a lot

84
00:03:39,190 --> 00:03:35,760
of mgso4

85
00:03:41,910 --> 00:03:39,200
the viscosity of the ocean fluid may be

86
00:03:43,350 --> 00:03:41,920
completely different from the pure water

87
00:03:47,110 --> 00:03:43,360
ocean

88
00:03:48,869 --> 00:03:47,120

however the there are no viscosity data

89
00:03:52,470 --> 00:03:48,879
under the temperature and pressure

90
00:03:56,550 --> 00:03:54,869
therefore this study aims to determine

91
00:03:58,390 --> 00:03:56,560
the temperature under pressure

92
00:04:01,429 --> 00:03:58,400
dependence of viscosity

93
00:04:03,589 --> 00:04:01,439
of aggregate mgso4 solutions at low

94
00:04:07,670 --> 00:04:03,599
temperature and high temp high pressure

95
00:04:10,149 --> 00:04:07,680
which can be applied to icy satellites

96
00:04:12,390 --> 00:04:10,159
in this study the viscosity of a 10

97
00:04:13,429 --> 00:04:12,400
weight percent acquires mgso for

98
00:04:16,469 --> 00:04:13,439
solution

99
00:04:18,390 --> 00:04:16,479
in these conditions

100
00:04:21,189 --> 00:04:18,400
was measured by the following sphere

101
00:04:25,430 --> 00:04:21,199
method using a diamond ambient cell

102
00:04:27,030 --> 00:04:25,440
a high pressure generator as shown here

103
00:04:29,030 --> 00:04:27,040
the temperature was controlled

104
00:04:32,230 --> 00:04:29,040
controlled by throwing hot

105
00:04:34,390 --> 00:04:32,240
and cold water through the dark and

106
00:04:38,230 --> 00:04:34,400
the pressure was determined using the

107
00:04:42,469 --> 00:04:40,310
the principle of the following sphere

108
00:04:45,430 --> 00:04:42,479
method is simple

109
00:04:46,790 --> 00:04:45,440
this method obtains a fluid viscosity by

110
00:04:49,749 --> 00:04:46,800
measuring the

111
00:04:51,110 --> 00:04:49,759
velocity of a falling sphere through the

112
00:04:54,390 --> 00:04:51,120
fluid

113
00:04:56,070 --> 00:04:54,400

this working equation is derived by

114
00:04:59,430 --> 00:04:56,080
considering the balance

115
00:05:00,390 --> 00:04:59,440
of gravity variancy and viscous

116
00:05:02,790 --> 00:05:00,400
resistance

117
00:05:05,430 --> 00:05:02,800
on the falling sphere and device

118
00:05:12,150 --> 00:05:05,440
collection factor

119
00:05:14,469 --> 00:05:12,160
a is the radius of the sphere

120
00:05:15,510 --> 00:05:14,479
rho is the density of the sphere and

121
00:05:18,870 --> 00:05:15,520
fluid

122
00:05:21,909 --> 00:05:18,880
respectively and g

123
00:05:27,670 --> 00:05:21,919
is the gravitational acceleration

124
00:05:31,110 --> 00:05:29,830
to acquire the velocity of the falling

125
00:05:35,029 --> 00:05:31,120
sphere in the dark

126
00:05:38,070 --> 00:05:35,039
i constructed this system this is a

127
00:05:39,110 --> 00:05:38,080
simplified image of the system and this

128
00:05:41,350 --> 00:05:39,120
is a

129
00:05:43,189 --> 00:05:41,360
picture of the dark diamond angle cell

130
00:05:46,870 --> 00:05:43,199
used in the experiment

131
00:05:49,590 --> 00:05:46,880
and a photo inside the cell

132
00:05:50,790 --> 00:05:49,600
the diamond army cell is mounted on a

133
00:05:53,590 --> 00:05:50,800
rotating stage

134
00:05:55,510 --> 00:05:53,600
and each rotation of the stage brings

135
00:05:58,870 --> 00:05:55,520
the sphere from the bottom

136
00:06:02,150 --> 00:05:58,880
to the top of the sample chamber

137
00:06:06,870 --> 00:06:02,160
then it can be dropped using

138
00:06:10,309 --> 00:06:06,880

light microscope and camera

139
00:06:12,790 --> 00:06:10,319
i monitored and recorded the drop motion

140
00:06:16,870 --> 00:06:12,800
then i measured the velocity of the

141
00:06:19,990 --> 00:06:16,880
sphere and calculated the viscosity

142
00:06:23,029 --> 00:06:20,000
let's move on to the result the plot

143
00:06:23,749 --> 00:06:23,039
on the left figure show the experimental

144
00:06:26,469 --> 00:06:23,759
results

145
00:06:26,790 --> 00:06:26,479
viscosity of magnesium sulfate solution

146
00:06:33,749 --> 00:06:26,800
at

147
00:06:37,749 --> 00:06:33,759
reference

148
00:06:42,390 --> 00:06:37,759
the viscosity value acquired ranged from

149
00:06:44,550 --> 00:06:42,400
1 to 10 meter pascal seconds

150
00:06:47,510 --> 00:06:44,560
on the right figure the viscosity of

151
00:06:50,790 --> 00:06:47,520
pure water is shown as a dashed line

152
00:06:53,909 --> 00:06:50,800
for comparison and the viscosity of

153
00:06:57,270 --> 00:06:53,919
various aqueous electro

154
00:07:01,350 --> 00:06:57,280
light solutions by reference is shown

155
00:07:01,589 --> 00:07:01,360
as a dotted line as with the viscosity

156
00:07:04,950 --> 00:07:01,599
of

157
00:07:06,150 --> 00:07:04,960
other accuracy mgso aqueous electrolyte

158
00:07:08,390 --> 00:07:06,160
solutions

159
00:07:10,870 --> 00:07:08,400
the pressure dependence of the viscosity

160
00:07:13,749 --> 00:07:10,880
of magnesium sulfate solution

161
00:07:14,230 --> 00:07:13,759
can be fitted by the quadratic equation

162
00:07:17,990 --> 00:07:14,240
shown

163
00:07:20,230 --> 00:07:18,000

by the solid line at all temperatures

164
00:07:21,270 --> 00:07:20,240
the viscosity of magnesium sulfate

165
00:07:26,710 --> 00:07:21,280
solution is

166
00:07:30,629 --> 00:07:28,710
using the pressure and temperature

167
00:07:33,270 --> 00:07:30,639
dependence of viscosity

168
00:07:34,230 --> 00:07:33,280
of the end in this study i calculated

169
00:07:37,270 --> 00:07:34,240
the viscosity

170
00:07:37,990 --> 00:07:37,280
at a given temperature and pressure i

171
00:07:41,670 --> 00:07:38,000
draw

172
00:07:44,469 --> 00:07:41,680
iso viscosity lines on the phase diagram

173
00:07:46,230 --> 00:07:44,479
of 10 weight percent magnesium sulphate

174
00:07:48,790 --> 00:07:46,240
solution

175
00:07:50,790 --> 00:07:48,800
the shaded area represents the

176
00:07:54,150 --> 00:07:50,800
temperature and pressure range of the

177
00:08:01,189 --> 00:07:57,430
while the viscosity of pure water ocean

178
00:08:05,589 --> 00:08:01,199
shown in the right figure is around

179
00:08:08,790 --> 00:08:05,599
1 or 2 meter pascal seconds the ocean of

180
00:08:11,749 --> 00:08:08,800
10 weight percent mgso4 solutions

181
00:08:13,430 --> 00:08:11,759
can vary from 1 to 10 mega pascal

182
00:08:16,230 --> 00:08:13,440
seconds

183
00:08:19,830 --> 00:08:16,240
one digit valuation depending on the

184
00:08:23,830 --> 00:08:22,390
i showed that viscosity of subsurface

185
00:08:27,029 --> 00:08:23,840
ocean fluid may be

186
00:08:29,110 --> 00:08:27,039
highly variable one digit in the case of

187
00:08:31,589 --> 00:08:29,120
10 weight percent of energy software

188
00:08:34,709 --> 00:08:31,599

solutions

189
00:08:36,469 --> 00:08:34,719
so i will introduce some implications

190
00:08:38,870 --> 00:08:36,479
for iso satellites

191
00:08:39,670 --> 00:08:38,880
this is the simplified cross-sectional

192
00:08:41,990 --> 00:08:39,680
installation

193
00:08:42,709 --> 00:08:42,000
of isosatellites with some possible

194
00:08:47,190 --> 00:08:42,719
phenomena

195
00:08:50,150 --> 00:08:47,200
related to viscosity and habitability

196
00:08:51,509 --> 00:08:50,160
viscosity relates to how ocean fluid

197
00:08:54,389 --> 00:08:51,519
moves

198
00:08:55,670 --> 00:08:54,399
it affects the convection style of the

199
00:08:59,350 --> 00:08:55,680
subsurface ocean

200
00:09:03,190 --> 00:08:59,360
and fluid movement velocity

201
00:09:04,949 --> 00:09:03,200
through rocks and ices

202
00:09:07,190 --> 00:09:04,959
therefore the time scale of

203
00:09:09,829 --> 00:09:07,200
differentiation of these bodies and

204
00:09:12,870 --> 00:09:09,839
photo saturation

205
00:09:14,949 --> 00:09:12,880
from an astrobiological point of view

206
00:09:18,310 --> 00:09:14,959
diffusion is one of the important

207
00:09:20,070 --> 00:09:18,320
keywords related to viscosity

208
00:09:21,509 --> 00:09:20,080
the diffusion coefficient in the

209
00:09:24,550 --> 00:09:21,519
solution can be

210
00:09:27,590 --> 00:09:24,560
written as the stocks einstein equation

211
00:09:31,430 --> 00:09:27,600
which says the diffusion coefficient is

212
00:09:34,070 --> 00:09:31,440
inversely proportional to the viscosity

213
00:09:34,470 --> 00:09:34,080

therefore viscosity variation affects

214
00:09:37,030 --> 00:09:34,480
the

215
00:09:37,910 --> 00:09:37,040
efficiency of material transport by

216
00:09:42,230 --> 00:09:37,920
diffusion

217
00:09:46,070 --> 00:09:42,240
the right process

218
00:09:49,590 --> 00:09:46,080
such as nutrient transportation

219
00:09:52,150 --> 00:09:49,600
let's move on to the protein as you know

220
00:09:52,870 --> 00:09:52,160
proteins are large molecules and are

221
00:09:56,389 --> 00:09:52,880
composed

222
00:09:59,430 --> 00:09:56,399
of long chains of amino acid

223
00:10:03,269 --> 00:09:59,440
in a solution proteins have

224
00:10:06,550 --> 00:10:03,279
variable structures in proteins

225
00:10:09,910 --> 00:10:06,560
processes such as folding and catalysis

226
00:10:10,870 --> 00:10:09,920
slowed by solution viscosity around the

227
00:10:17,590 --> 00:10:10,880
protein

228
00:10:22,150 --> 00:10:20,150
now let me touch on the implication

229
00:10:24,550 --> 00:10:22,160
based on the study of the prebiotic

230
00:10:27,990 --> 00:10:24,560
chemistry on the earth

231
00:10:29,829 --> 00:10:28,000
when a double strand like dna diffuses

232
00:10:32,470 --> 00:10:29,839
apart

233
00:10:33,750 --> 00:10:32,480
high viscosity makes it difficult for

234
00:10:36,670 --> 00:10:33,760
these strands to

235
00:10:37,829 --> 00:10:36,680
rebind again allowing small

236
00:10:42,949 --> 00:10:37,839
oligonucleotides

237
00:10:46,069 --> 00:10:42,959
to bind each strand for replication

238
00:10:49,030 --> 00:10:46,079

although this study assumes much higher

239
00:10:49,910 --> 00:10:49,040
solvent viscosity than measured in my

240
00:10:52,550 --> 00:10:49,920
study

241
00:10:53,430 --> 00:10:52,560
and its discussion includes temperature

242
00:10:56,630 --> 00:10:53,440
increase and

243
00:10:57,829 --> 00:10:56,640
decreasing degree cycle this has an

244
00:11:00,630 --> 00:10:57,839
implication for the

245
00:11:02,150 --> 00:11:00,640
possible biologic process under the high

246
00:11:06,310 --> 00:11:02,160
viscosity condition

247
00:11:13,829 --> 00:11:10,069
in summary viscosity variation

248
00:11:16,310 --> 00:11:13,839
of the subsurface ocean fluid one digit

249
00:11:17,350 --> 00:11:16,320
in the case of thin weight-based mgso4

250
00:11:20,230 --> 00:11:17,360
solutions

251
00:11:22,470 --> 00:11:20,240
occur due to pressure temperature and

252
00:11:24,870 --> 00:11:22,480
concentration change

253
00:11:26,150 --> 00:11:24,880
which might affect convection

254
00:11:32,310 --> 00:11:26,160
differentiation