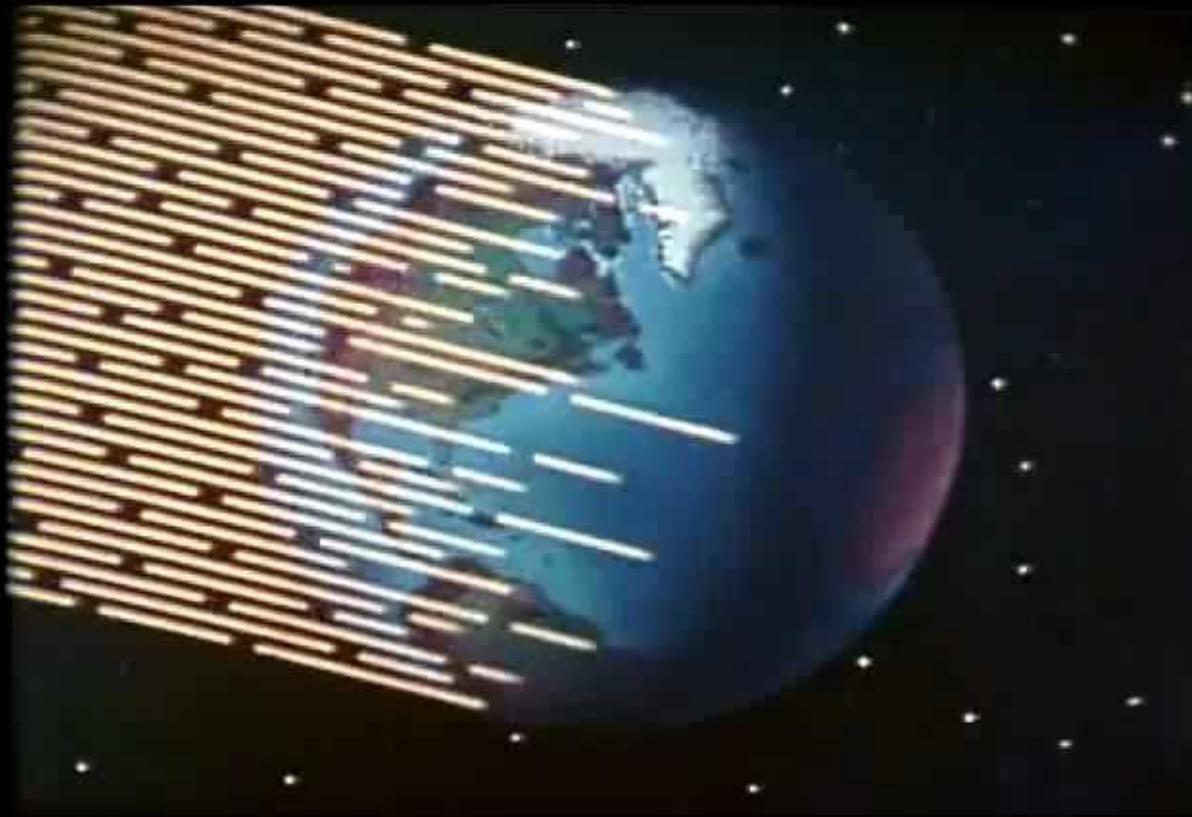

1
00:00:14,420 --> 00:00:12,770
each year since 1970 bleeding space

2
00:00:16,490 --> 00:00:14,430
scientists from throughout the world

3
00:00:18,710 --> 00:00:16,500
have gathered in Houston at NASA's

4
00:00:20,929 --> 00:00:18,720
Johnson Space Center and the lunar and

5
00:00:24,920 --> 00:00:20,939
planetary institute to exchange ideas

6
00:00:26,479 --> 00:00:24,930
and information the nineteen seventy

7
00:00:28,700 --> 00:00:26,489
nine conference marks a special

8
00:00:31,930 --> 00:00:28,710
observance it is the tenth anniversary

9
00:00:35,240 --> 00:00:31,940
of the first Apollo landing on the moon

10
00:00:37,700 --> 00:00:35,250
in the space sciences where it is common

11
00:00:41,840 --> 00:00:37,710
to deal with eons and millennia ten

12
00:00:44,479 --> 00:00:41,850
years is a mere blink of the eye get in

13
00:00:47,180 --> 00:00:44,489

that brief span those here today have

14
00:00:51,049 --> 00:00:47,190
witnessed almost total upheaval in their

15
00:00:53,479 --> 00:00:51,059
respective scientific field to say that

16
00:00:56,180 --> 00:00:53,489
we have undergone a revolution in lunar

17
00:00:58,910 --> 00:00:56,190
and planetary science is more than just

18
00:01:36,700 --> 00:00:58,920
rhetoric when you consider how far we've

19
00:01:42,260 --> 00:01:40,130
before the Apollo era scientists who

20
00:01:44,660 --> 00:01:42,270
wanted to learn more about the formation

21
00:01:48,109 --> 00:01:44,670
and evolution of the solar system didn't

22
00:01:51,109 --> 00:01:48,119
have much to work with from the entire

23
00:01:53,149 --> 00:01:51,119
solar system they had only two sources

24
00:01:56,179 --> 00:01:53,159
of materials available for direct

25
00:01:59,569 --> 00:01:56,189
analysis meteorites that had fallen to

26
00:02:07,740 --> 00:01:59,579
Earth from outer space and of course the

27
00:02:12,580 --> 00:02:10,960
but the dynamic nature of the earth has

28
00:02:15,280 --> 00:02:12,590
resulted in the processing and

29
00:02:17,949 --> 00:02:15,290
reprocessing of its rocks and soils for

30
00:02:24,900 --> 00:02:17,959
hundreds of millions of years totally

31
00:02:30,100 --> 00:02:28,180
as a result on earth Rock more than

32
00:02:34,390 --> 00:02:30,110
three billion years old is a rare find

33
00:02:38,350 --> 00:02:34,400
even today most earth materials are far

34
00:02:40,449 --> 00:02:38,360
younger but meteorites that have fallen

35
00:02:44,979 --> 00:02:40,459
to earth were found to be extremely old

36
00:02:47,710 --> 00:02:44,989
the oldest about 4.6 billion years and

37
00:02:52,030 --> 00:02:47,720
most scientists believe that was near

38
00:02:54,100 --> 00:02:52,040

the time the solar system formed so

39
00:02:56,920 --> 00:02:54,110
between the ages of earth rocks and

40
00:02:59,890 --> 00:02:56,930
meteorites there was at the time a gap

41
00:03:05,130 --> 00:02:59,900
of a billion and a half years a period

42
00:03:10,260 --> 00:03:08,220
blown before the Apollo era the idea

43
00:03:12,090 --> 00:03:10,270
that perhaps knowing the moon would lead

44
00:03:14,100 --> 00:03:12,100
to a better understanding of Earth and

45
00:03:17,130 --> 00:03:14,110
the solar system had occurred to many

46
00:03:23,150 --> 00:03:17,140
investigators and with the telescope

47
00:03:28,920 --> 00:03:25,860
they charted the dominant light shaded

48
00:03:32,280 --> 00:03:28,930
areas the highlands pitted and scarred

49
00:03:35,550 --> 00:03:32,290
from eons of meteoroid impacts and the

50
00:03:38,070 --> 00:03:35,560
smooth dark basins the Galileo in the

51
00:03:42,000 --> 00:03:38,080
early 17th century had called the maurya

52
00:03:43,949 --> 00:03:42,010
for lunar seas they were able to

53
00:03:46,890 --> 00:03:43,959
calculate the height of lunar mountains

54
00:03:49,800 --> 00:03:46,900
some of which rise five kilometers above

55
00:03:52,440 --> 00:03:49,810
the terrain they knew the length of

56
00:03:54,630 --> 00:03:52,450
ancient scarps or faults which may slice

57
00:03:58,770 --> 00:03:54,640
across the moon's face for a hundred of

58
00:04:02,160 --> 00:03:58,780
more kilometers from pole to pole they

59
00:04:05,130 --> 00:04:02,170
studied craters older ones without lions

60
00:04:06,900 --> 00:04:05,140
barely visible newer ones with streaks

61
00:04:10,229 --> 00:04:06,910
of displaced rubble radiating out from

62
00:04:15,990 --> 00:04:10,239
their centres craters overlying craters

63
00:04:17,819 --> 00:04:16,000

and craters within craters scientists

64
00:04:21,210 --> 00:04:17,829
thus came to know the moon's surface

65
00:04:23,790 --> 00:04:21,220
features in minut detail yet beyond what

66
00:04:26,820 --> 00:04:23,800
they saw they could only speculate about

67
00:04:29,730 --> 00:04:26,830
its origin its age its chemical

68
00:04:32,270 --> 00:04:29,740
composition its structure and about what

69
00:04:35,310 --> 00:04:32,280
processes had shaped it in the past

70
00:04:41,640 --> 00:04:35,320
there was no shortage of theories but

71
00:04:45,120 --> 00:04:41,650
there were very few facts by the late

72
00:04:47,250 --> 00:04:45,130
1950s improved technology in the form of

73
00:04:53,100 --> 00:04:47,260
automated spacecraft gave us a new

74
00:04:55,440 --> 00:04:53,110
perspective of the moon these unmanned

75
00:04:58,200 --> 00:04:55,450
probes from both the Soviet Union and

76
00:05:01,050 --> 00:04:58,210
the United States sent back images never

77
00:05:04,260 --> 00:05:01,060
before seen by the telescope including

78
00:05:07,170 --> 00:05:04,270
the first views of the moon's backside

79
00:05:09,120 --> 00:05:07,180
from surveyor spacecraft that soft

80
00:05:11,280 --> 00:05:09,130
landed on the surface there were even

81
00:05:13,760 --> 00:05:11,290
some basic data on the nature and

82
00:05:17,340 --> 00:05:13,770
chemistry of lunar surface materials

83
00:05:19,770 --> 00:05:17,350
here too was the first concrete proof

84
00:05:22,080 --> 00:05:19,780
that landing craft and astronauts would

85
00:05:25,740 --> 00:05:22,090
not sink from site in the Padre lunar

86
00:05:28,410 --> 00:05:25,750
dust yet for all the centuries of

87
00:05:31,260 --> 00:05:28,420
telescopic study and more recently the

88
00:05:33,480 --> 00:05:31,270

flurry of automated moon probes the

89
00:05:36,330 --> 00:05:33,490
detailed analysis of earth materials and

90
00:05:39,080 --> 00:05:36,340
meteorites in spite of all that was

91
00:05:41,610 --> 00:05:39,090
accomplished prior to the Apollo program

92
00:05:44,280 --> 00:05:41,620
we knew next to nothing about the

93
00:05:51,120 --> 00:05:44,290
history composition and structure of the

94
00:05:53,630 --> 00:05:51,130
moon extremely different views were held

95
00:05:56,910 --> 00:05:53,640
by eminent scientists the world over

96
00:05:58,980 --> 00:05:56,920
theories and opinions snowball and in

97
00:06:03,600 --> 00:05:58,990
the absence of facts they clashed

98
00:06:05,600 --> 00:06:03,610
head-on unless we could obtain pieces of

99
00:06:07,710 --> 00:06:05,610
the moon for study and analysis

100
00:06:28,250 --> 00:06:07,720
understanding it would remain an

101
00:06:33,050 --> 00:06:30,659
she know you're looking great coming up

102
00:06:38,540 --> 00:06:33,060
now do I twentieth nineteen sixty-nine

103
00:06:45,510 --> 00:06:38,550
the dream became reality 60-second

104
00:06:48,620 --> 00:06:45,520
Python forward forward that's pretty

105
00:06:51,659 --> 00:06:48,630
feet down to an ABS picking up some dust

106
00:06:55,860 --> 00:06:51,669
City Pete's two and a half down make

107
00:06:57,750 --> 00:06:55,870
shadows for forward four forward

108
00:07:08,129 --> 00:06:57,760
drifting to the right little headache

109
00:07:15,719 --> 00:07:11,879
I'm back right okay engine stop we copy

110
00:07:19,890 --> 00:07:15,729
you down eagle Griffin fan quality base

111
00:07:22,739 --> 00:07:19,900
here the eagle has landed tranquility we

112
00:07:25,679 --> 00:07:22,749
copy on a crafter years of planet the

113
00:07:30,239 --> 00:07:25,689

detailed on-site exploration of the moon

114
00:07:33,209 --> 00:07:30,249
had begun and briefly the world stopped

115
00:07:41,369 --> 00:07:33,219
as people everywhere shared this

116
00:07:43,890 --> 00:07:41,379
greatest of moments even scientists had

117
00:07:46,499 --> 00:07:43,900
spent years preparing for this day were

118
00:07:52,320 --> 00:07:46,509
awestruck by the sights and sounds from

119
00:07:54,719 --> 00:07:52,330
the memory making the most of their

120
00:07:57,420 --> 00:07:54,729
brief time on the surface the astronauts

121
00:08:00,240 --> 00:07:57,430
set up a small science station to return

122
00:08:02,459 --> 00:08:00,250
data back to earth it was the forerunner

123
00:08:05,610 --> 00:08:02,469
of other stations erected on later

124
00:08:07,559 --> 00:08:05,620
missions it was this network that would

125
00:08:10,200 --> 00:08:07,569
allow scientists to keep track the

126
00:08:14,159 --> 00:08:10,210
balloons geologic behavior for several

127
00:08:16,379 --> 00:08:14,169
years tranquility base presented the

128
00:08:19,619 --> 00:08:16,389
Apollo 11 crew with an assortment of

129
00:08:22,350 --> 00:08:19,629
rocks and soils most of it appeared to

130
00:08:25,649 --> 00:08:22,360
be the Celtic rock the most common form

131
00:08:27,749 --> 00:08:25,659
of volcanic lava whether or not there's

132
00:08:30,119 --> 00:08:27,759
ever been volcanic eruptions on the moon

133
00:08:33,509 --> 00:08:30,129
had been one of the major pre Apollo

134
00:08:35,850 --> 00:08:33,519
debates now within minutes after the

135
00:08:39,659 --> 00:08:35,860
cruise stepped onto the lunar surface it

136
00:08:43,019 --> 00:08:39,669
was no longer an issue but quick and

137
00:08:45,420 --> 00:08:43,029
easy answers would be the exception most

138
00:08:47,670 --> 00:08:45,430

discoveries about the moon would have to

139
00:08:50,100 --> 00:08:47,680
be built piece by piece from tiny

140
00:08:58,590 --> 00:08:50,110
fragments of information during the many

141
00:09:03,700 --> 00:09:01,330
when Apollo 11 returned to earth a

142
00:09:07,020 --> 00:09:03,710
carefully developed program of lunar

143
00:09:09,450 --> 00:09:07,030
samples investigation was set in motion

144
00:09:12,580 --> 00:09:09,460
geologists physicists chemists

145
00:09:14,980 --> 00:09:12,590
biologists several hundred scientists

146
00:09:21,710 --> 00:09:14,990
from here and abroad had pooled their

147
00:09:26,389 --> 00:09:23,809
although investigators worked with the

148
00:09:29,059 --> 00:09:26,399
same types of samples they look for

149
00:09:32,809 --> 00:09:29,069
different things some groups measured

150
00:09:34,699 --> 00:09:32,819
ages and chemical compositions others

151
00:09:37,730 --> 00:09:34,709
worked on the chemistry of minerals and

152
00:09:40,610 --> 00:09:37,740
their atomic structure while some

153
00:09:44,840 --> 00:09:40,620
experimented defining the properties of

154
00:09:47,869 --> 00:09:44,850
lunar rocks and soils but not all of the

155
00:09:49,939 --> 00:09:47,879
investigators worked with samples some

156
00:09:52,490 --> 00:09:49,949
of them read electronic blips and

157
00:09:54,110 --> 00:09:52,500
tracings the signals coming from the

158
00:09:57,769 --> 00:09:54,120
geophysical instruments of the lunar

159
00:10:00,920 --> 00:09:57,779
science station here a running account

160
00:10:02,689 --> 00:10:00,930
of the moon's internal activity the

161
00:10:05,449 --> 00:10:02,699
basis for determining its structure

162
00:10:12,949 --> 00:10:05,459
would be recorded and deciphered for the

163
00:10:14,960 --> 00:10:12,959

next several years the techniques and

164
00:10:23,810 --> 00:10:14,970
procedures for investigating the moon

165
00:10:29,960 --> 00:10:26,830
the goal now was continued exploration

166
00:10:32,810 --> 00:10:29,970
to obtain a variety of lunar materials

167
00:10:34,850 --> 00:10:32,820
from different geological terrain and to

168
00:10:40,550 --> 00:10:34,860
establish a network of scientific

169
00:10:43,640 --> 00:10:40,560
stations over the next three and a half

170
00:10:47,090 --> 00:10:43,650
years Apollo 11 was followed by five

171
00:10:49,430 --> 00:10:47,100
more lunar landings all of the landing

172
00:10:56,360 --> 00:10:49,440
sites were near the lunar equator on the

173
00:11:02,290 --> 00:10:56,370
earth-facing side first mission to last

174
00:11:09,140 --> 00:11:05,900
big factor was the lunar rover used on

175
00:11:11,720 --> 00:11:09,150
the last three missions with this new

176
00:11:14,540 --> 00:11:11,730
mobility crewmen ranged further from

177
00:11:16,730 --> 00:11:14,550
home base and along with modifications

178
00:11:18,950 --> 00:11:16,740
to the lunar module and the spacesuit

179
00:11:26,750 --> 00:11:18,960
they were able to stay longer at the

180
00:11:29,060 --> 00:11:26,760
exploration site on the final mission

181
00:11:32,600 --> 00:11:29,070
astronauts could extend their total

182
00:11:34,940 --> 00:11:32,610
exploration time to 75 hours quite a

183
00:11:38,750 --> 00:11:34,950
contrast to the two and a half hours of

184
00:11:40,490 --> 00:11:38,760
Apollo 11 more and better measurements

185
00:11:42,800 --> 00:11:40,500
were also transmitted from the lunar

186
00:11:47,360 --> 00:11:42,810
science stations which grew steadily in

187
00:11:49,730 --> 00:11:47,370
size and sophistication sample

188
00:11:51,680 --> 00:11:49,740

collecting to became more selective and

189
00:11:55,670 --> 00:11:51,690
better documented on the later missions

190
00:12:09,370 --> 00:11:55,680
and for the first time on Apollo 17 a

191
00:12:14,000 --> 00:12:09,380
geologist was a member of the crew on

192
00:12:16,430 --> 00:12:14,010
December 14 1972 the last Apollo crew

193
00:12:19,010 --> 00:12:16,440
lifted from the lunar surface and with

194
00:12:22,850 --> 00:12:19,020
them the exploratory phase of Apollo

195
00:12:25,310 --> 00:12:22,860
came to an end but the scientific phase

196
00:12:27,890 --> 00:12:25,320
which by then was well into its third

197
00:12:34,740 --> 00:12:27,900
year had already answered many of the

198
00:12:40,320 --> 00:12:38,100
the story that began to emerge told of a

199
00:12:44,910 --> 00:12:40,330
moon far more interesting and complex

200
00:12:47,970 --> 00:12:44,920
than ever anticipated for one thing moon

201
00:12:50,430 --> 00:12:47,980
rocks were found to be very old falling

202
00:12:53,180 --> 00:12:50,440
in a range from about three billion to

203
00:12:57,180 --> 00:12:53,190
well over four billion years

204
00:12:58,800 --> 00:12:57,190
significantly moon rock ages began about

205
00:13:02,310 --> 00:12:58,810
where the ages of the oldest preserved

206
00:13:04,980 --> 00:13:02,320
earth rocks left off so in learning

207
00:13:06,990 --> 00:13:04,990
about the moons past scientists were

208
00:13:12,810 --> 00:13:07,000
also filling in pieces of the missing

209
00:13:15,120 --> 00:13:12,820
history of the earth no new chemical

210
00:13:17,340 --> 00:13:15,130
elements were discovered but there were

211
00:13:21,540 --> 00:13:17,350
minerals that scientists had not seen

212
00:13:25,110 --> 00:13:21,550
before the moon was found to have no

213
00:13:30,450 --> 00:13:25,120

free oxygen no water and no trace of

214
00:13:32,130 --> 00:13:30,460
life present or past seismic activity

215
00:13:35,550 --> 00:13:32,140
inside the moon was found to be

216
00:13:39,329 --> 00:13:35,560
extremely weak only about 110 billions

217
00:13:41,550 --> 00:13:39,339
of the activity inside the earth except

218
00:13:43,950 --> 00:13:41,560
for the impact of small meteoroids and

219
00:13:46,680 --> 00:13:43,960
the steady stream of atomic particles

220
00:13:49,530 --> 00:13:46,690
from the Sun the moon explored by the

221
00:13:55,650 --> 00:13:49,540
astronauts had been quiet and inactive

222
00:13:58,290 --> 00:13:55,660
for the last three billion years but the

223
00:14:01,740 --> 00:13:58,300
investigations show it was not always so

224
00:14:06,079 --> 00:14:01,750
calm rocks from the lunar highlands

225
00:14:08,760 --> 00:14:06,089
revealed an extremely violent beginning

226
00:14:12,090 --> 00:14:08,770
almost four and a half billion years ago

227
00:14:15,150 --> 00:14:12,100
shortly after the moon had formed its

228
00:14:18,180 --> 00:14:15,160
entire outer shell was a seething ocean

229
00:14:21,660 --> 00:14:18,190
of molten rock melting to adapt the from

230
00:14:24,670 --> 00:14:21,670
100 to 300 kilometres

231
00:14:27,730 --> 00:14:24,680
during the next 100 million years it

232
00:14:31,120 --> 00:14:27,740
began to cool and the outer shell began

233
00:14:35,860 --> 00:14:31,130
to solidify minerals began to

234
00:14:39,010 --> 00:14:35,870
crystallize high-density minerals tended

235
00:14:43,060 --> 00:14:39,020
to sink low density minerals floated to

236
00:14:46,180 --> 00:14:43,070
the top when cooling and solidification

237
00:14:48,100 --> 00:14:46,190
were complete these new distributions of

238
00:14:55,120 --> 00:14:48,110

minerals had formed the separate layers

239
00:14:57,990 --> 00:14:55,130
of crust mantle and core this process

240
00:15:00,820 --> 00:14:58,000
caught a lot of scientists by surprise

241
00:15:05,470 --> 00:15:00,830
melting and separation in the layers had

242
00:15:07,870 --> 00:15:05,480
never been proposed for the moon what's

243
00:15:10,660 --> 00:15:07,880
left of the early lunar crust after

244
00:15:12,730 --> 00:15:10,670
being torn apart by meteoroids is the

245
00:15:17,680 --> 00:15:12,740
light colored material we now call the

246
00:15:23,950 --> 00:15:20,800
but even as it formed meteoroids were

247
00:15:25,600 --> 00:15:23,960
pounding it to bits scientists are not

248
00:15:27,850 --> 00:15:25,610
sure about the frequency or the

249
00:15:30,790 --> 00:15:27,860
intensity of cratering during the next

250
00:15:33,280 --> 00:15:30,800
billion years however they are certain

251
00:15:37,150 --> 00:15:33,290
that about four billion years ago the

252
00:15:39,310 --> 00:15:37,160
devastation reached a peak the clues

253
00:15:42,010 --> 00:15:39,320
were found in a class of samples called

254
00:15:44,620 --> 00:15:42,020
breccias which are made up of fragments

255
00:15:47,860 --> 00:15:44,630
of different rocks all broken and welded

256
00:15:52,870 --> 00:15:47,870
together by heat some containing tiny

257
00:15:54,790 --> 00:15:52,880
spheres of glass with Bret she is

258
00:15:57,730 --> 00:15:54,800
consistently showing a gym Prince

259
00:16:01,330 --> 00:15:57,740
centered around four billion years the

260
00:16:03,370 --> 00:16:01,340
evidence was compelling at that time the

261
00:16:07,380 --> 00:16:03,380
lunar surface must have been bombarded

262
00:16:10,180 --> 00:16:07,390
and broken up on a massive scale a

263
00:16:13,200 --> 00:16:10,190

population of extremely large bodies

264
00:16:18,190 --> 00:16:13,210
some as much as 50 kilometres across

265
00:16:20,890 --> 00:16:18,200
smashed into the moon they blasted the

266
00:16:25,540 --> 00:16:20,900
crust apart and gouged out the giant

267
00:16:28,330 --> 00:16:25,550
Mari basins the largest of the lasons

268
00:16:33,160 --> 00:16:28,340
Mari yttrium is big enough to

269
00:16:35,230 --> 00:16:33,170
accommodate most of Western Europe the

270
00:16:37,720 --> 00:16:35,240
barrage in the moon was so intense that

271
00:16:41,260 --> 00:16:37,730
most likely the earth received a

272
00:16:43,690 --> 00:16:41,270
simultaneous pounding probably the whole

273
00:16:46,660 --> 00:16:43,700
inner solar system was teeming with the

274
00:16:50,730 --> 00:16:46,670
leftovers of formation the loose debris

275
00:16:54,370 --> 00:16:50,740
that had not been collected into planets

276
00:16:57,130 --> 00:16:54,380
after this major Cataclysm the cratering

277
00:16:59,620 --> 00:16:57,140
rate began to subside and the solar

278
00:17:03,460 --> 00:16:59,630
system rapidly became a fairly clean

279
00:17:06,340 --> 00:17:03,470
place by now the moon the earth and the

280
00:17:10,960 --> 00:17:06,350
other planets had swept up most of the

281
00:17:13,000 --> 00:17:10,970
loose debris the next stage of lunar

282
00:17:17,370 --> 00:17:13,010
history was recorded in the basaltic

283
00:17:22,710 --> 00:17:20,100
some 100 million years after the heavy

284
00:17:25,170 --> 00:17:22,720
bombardment ended heat from decay of

285
00:17:28,950 --> 00:17:25,180
radioactive elements began to build up

286
00:17:32,490 --> 00:17:28,960
inside the moon eventually getting hot

287
00:17:35,190 --> 00:17:32,500
enough to melt the rocky material in

288
00:17:37,410 --> 00:17:35,200

time as the melting spread the

289
00:17:39,390 --> 00:17:37,420
accumulated lavas were forced upward

290
00:17:41,550 --> 00:17:39,400
through false and fissures to the

291
00:17:51,120 --> 00:17:41,560
surface where they began to fill the

292
00:17:53,130 --> 00:17:51,130
large basins filling the basins forming

293
00:17:56,220 --> 00:17:53,140
the lunar Marya much as they now appear

294
00:18:01,710 --> 00:17:56,230
was not however the result of a single

295
00:18:04,560 --> 00:18:01,720
rampaging lava flow age dating show that

296
00:18:06,840 --> 00:18:04,570
lava was extruded intermittently in one

297
00:18:10,470 --> 00:18:06,850
place or another for almost a billion

298
00:18:15,990 --> 00:18:10,480
years from three point nine to three

299
00:18:18,450 --> 00:18:16,000
billion years ago after that the moon

300
00:18:21,090 --> 00:18:18,460
settled down to a quieter existence and

301
00:18:25,500 --> 00:18:21,100
has remained essentially the same to the

302
00:18:27,390 --> 00:18:25,510
present day among the subtle changes

303
00:18:30,330 --> 00:18:27,400
which have continued on the moon is

304
00:18:32,820 --> 00:18:30,340
solar wind bombardment the steady flow

305
00:18:36,900 --> 00:18:32,830
of atomic particles streaming outward

306
00:18:39,510 --> 00:18:36,910
from the Sun particles striking the moon

307
00:18:42,120 --> 00:18:39,520
many millions of years ago left their

308
00:18:46,500 --> 00:18:42,130
evidence embedded in lunar materials and

309
00:18:48,780 --> 00:18:46,510
these can be detected today this

310
00:18:50,940 --> 00:18:48,790
scanning electron microscope for example

311
00:18:53,280 --> 00:18:50,950
is studying the tracks left by solar

312
00:18:56,790 --> 00:18:53,290
particles as they pass through a lunar

313
00:18:58,950 --> 00:18:56,800

sample by making such precise

314
00:19:01,050 --> 00:18:58,960
measurements scientists are able to

315
00:19:05,040 --> 00:19:01,060
construct a long-term history of the

316
00:19:07,050 --> 00:19:05,050
sun's activity the surprising result is

317
00:19:11,210 --> 00:19:07,060
that the Sun has been a fairly well

318
00:19:14,130 --> 00:19:11,220
behaved star for many millions of years

319
00:19:16,760 --> 00:19:14,140
there were no noticeable Sun deviations

320
00:19:19,620 --> 00:19:16,770
even during the Ice Ages of Earth a

321
00:19:24,910 --> 00:19:19,630
finding attends to weaken theories the

322
00:19:31,630 --> 00:19:27,860
the samples did not completely satisfy a

323
00:19:36,230 --> 00:19:31,640
major pre Apollo enigma how the moon

324
00:19:39,400 --> 00:19:36,240
originated processing of a lunar

325
00:19:42,980 --> 00:19:39,410
materials by melting of the outer shell

326
00:19:46,490 --> 00:19:42,990
meteoroid bombardment and the long

327
00:19:49,750 --> 00:19:46,500
volcanic phase destroyed all traces of

328
00:19:52,400 --> 00:19:49,760
the moon's primitive starting material

329
00:19:54,680 --> 00:19:52,410
however investigators have recently

330
00:19:57,470 --> 00:19:54,690
discovered certain earth-moon chemical

331
00:19:58,970 --> 00:19:57,480
similarities that can be explained only

332
00:20:02,270 --> 00:19:58,980
if they originated in the same

333
00:20:05,710 --> 00:20:02,280
neighborhood but the mechanism of origin

334
00:20:08,480 --> 00:20:05,720
could have happened any of three ways

335
00:20:10,460 --> 00:20:08,490
the moon could have been torn from the

336
00:20:13,370 --> 00:20:10,470
primitive earth and captured in its

337
00:20:18,230 --> 00:20:15,800
the moon at earth could have accreted

338
00:20:23,480 --> 00:20:18,240

from particles in the same vicinity at

339
00:20:25,430 --> 00:20:23,490
the same time or the moon could have

340
00:20:28,730 --> 00:20:25,440
condensed out of an early primitive

341
00:20:31,220 --> 00:20:28,740
atmosphere surrounding earth lunar

342
00:20:39,800 --> 00:20:31,230
origin remains an open question that

343
00:20:42,260 --> 00:20:39,810
will not be easily solved before the

344
00:20:44,770 --> 00:20:42,270
Apollo program scientists were struck by

345
00:20:47,240 --> 00:20:44,780
the differences in the earth and whom

346
00:20:49,550 --> 00:20:47,250
many believe the moon was a solid

347
00:20:51,860 --> 00:20:49,560
homogeneous sphere related more to

348
00:20:55,670 --> 00:20:51,870
primitive meteorites than it was to the

349
00:20:58,340 --> 00:20:55,680
planets but after analyzing lunar

350
00:21:00,830 --> 00:20:58,350
materials seeing the patterns of

351
00:21:03,170 --> 00:21:00,840
chemical elements the minerals that had

352
00:21:05,530 --> 00:21:03,180
formed from these elements on the

353
00:21:08,720 --> 00:21:05,540
arrangements of these men rules in rocks

354
00:21:11,300 --> 00:21:08,730
they came to realize that the moon had

355
00:21:14,900 --> 00:21:11,310
all the earmarks of an evolved planet

356
00:21:16,790 --> 00:21:14,910
with a history all its own the

357
00:21:18,980 --> 00:21:16,800
difference they found was in the

358
00:21:21,860 --> 00:21:18,990
separate paths of evolution the Earth

359
00:21:24,110 --> 00:21:21,870
and Moon have taken primarily the result

360
00:21:28,430 --> 00:21:24,120
of their different sizes and starting

361
00:21:30,890 --> 00:21:28,440
conditions if the earth and moon formed

362
00:21:33,050 --> 00:21:30,900
near each other they probably started

363
00:21:38,630 --> 00:21:33,060

out with a similar mixture of elements

364
00:21:41,630 --> 00:21:38,640
such as aluminum silicon and oxygen like

365
00:21:43,910 --> 00:21:41,640
the moon the earth probably experienced

366
00:21:48,320 --> 00:21:43,920
an early melting phase that resulted in

367
00:21:50,630 --> 00:21:48,330
its separation in two layers the heavy

368
00:21:53,270 --> 00:21:50,640
bombardment phase discovered on the moon

369
00:21:54,499 --> 00:21:53,280
must have been sustained equally by the

370
00:21:57,169 --> 00:21:54,509
earth

371
00:22:00,019 --> 00:21:57,179
but during the phase of internal melting

372
00:22:03,169 --> 00:22:00,029
and volcanism their common ancestry

373
00:22:07,339 --> 00:22:03,179
began to diverge in a way that would set

374
00:22:10,219 --> 00:22:07,349
them apart forever for one thing the

375
00:22:12,039 --> 00:22:10,229
moon being smaller had a lesser share of

376
00:22:14,919 --> 00:22:12,049
radioactive elements than the earth and

377
00:22:20,209 --> 00:22:14,929
these are the elements that in decaying

378
00:22:23,299 --> 00:22:20,219
generate heat also the heat that was

379
00:22:25,999 --> 00:22:23,309
produced was lost more rapidly simply

380
00:22:30,979 --> 00:22:26,009
because the smaller the body the faster

381
00:22:33,439 --> 00:22:30,989
it loses heat the larger earth with a

382
00:22:36,519 --> 00:22:33,449
larger store of heat making elements and

383
00:22:39,339 --> 00:22:36,529
the potential to hold heat longer

384
00:22:41,899 --> 00:22:39,349
developed a massive molten iron core

385
00:22:47,269 --> 00:22:41,909
that would help keep our planet running

386
00:22:50,930 --> 00:22:47,279
as it does now for billions of years the

387
00:22:53,209 --> 00:22:50,940
intense heat powers volcanoes recycling

388
00:22:56,869 --> 00:22:53,219

rocky materials to continually produce

389
00:22:59,779 --> 00:22:56,879
new crust of the surface heat from

390
00:23:02,559 --> 00:22:59,789
radioactive decay also created a narrow

391
00:23:05,689 --> 00:23:02,569
zone of molten rock just below the crust

392
00:23:09,999 --> 00:23:05,699
it acts as a sort of lubricant allowing

393
00:23:13,129 --> 00:23:10,009
the crust to shift about as thin plates

394
00:23:15,229 --> 00:23:13,139
it is these lateral plate movements that

395
00:23:21,680 --> 00:23:15,239
have given the earth that's wide variety

396
00:23:29,480 --> 00:23:25,260
the moon with a crust so thick and rigid

397
00:23:32,610 --> 00:23:29,490
never experienced lateral playful but

398
00:23:34,620 --> 00:23:32,620
its mountains which tend to lie in rings

399
00:23:37,200 --> 00:23:34,630
on the periphery of the large basins

400
00:23:38,910 --> 00:23:37,210
were built from materials displaced from

401
00:23:43,440 --> 00:23:38,920
the basins when they were formed by

402
00:23:45,900 --> 00:23:43,450
impact nor were lunar rills formed by

403
00:23:48,120 --> 00:23:45,910
crustal shifting or by the cutting

404
00:23:51,540 --> 00:23:48,130
action of water as they often are on

405
00:23:54,000 --> 00:23:51,550
earth scientists believe they are old

406
00:23:58,860 --> 00:23:54,010
lava tubes that have collapsed over the

407
00:24:01,140 --> 00:23:58,870
last 3 billion years at the time the

408
00:24:04,470 --> 00:24:01,150
moon was losing heat it was also losing

409
00:24:08,280 --> 00:24:04,480
its volcanic gases and it is from such

410
00:24:10,560 --> 00:24:08,290
gases that atmospheres form but with a

411
00:24:13,770 --> 00:24:10,570
weak gravitational field again the

412
00:24:18,390 --> 00:24:13,780
result of size the moon was unable to

413
00:24:21,660 --> 00:24:18,400

retain even the heaviest gases Earth's

414
00:24:23,790 --> 00:24:21,670
gravity held most of its gases gases

415
00:24:27,840 --> 00:24:23,800
that eventually formed a primitive

416
00:24:40,580 --> 00:24:30,720
and from that atmosphere came torrents

417
00:24:47,230 --> 00:24:43,220
the patient's were filled and the earth

418
00:24:50,120 --> 00:24:47,240
had oceans and seas lakes and rivers and

419
00:25:04,639 --> 00:24:50,130
from the water life itself would

420
00:25:09,779 --> 00:25:07,560
the moon with no chance of forming an

421
00:25:12,570 --> 00:25:09,789
atmosphere could not develop even the

422
00:25:15,749 --> 00:25:12,580
lowest forms of life it was just too

423
00:25:18,089 --> 00:25:15,759
small to make it after about a billion

424
00:25:21,440 --> 00:25:18,099
and a half years it reached the terminal

425
00:25:24,089 --> 00:25:21,450
phase of its relatively short evolution

426
00:25:26,849 --> 00:25:24,099
the story of the moon is still not

427
00:25:28,859 --> 00:25:26,859
complete although its historical outline

428
00:25:31,649 --> 00:25:28,869
once it formed has been firmly

429
00:25:34,019 --> 00:25:31,659
established its basic structure and

430
00:25:37,619 --> 00:25:34,029
chemistry have been determined many

431
00:25:39,930 --> 00:25:37,629
questions remain only about ten percent

432
00:25:41,999 --> 00:25:39,940
of the samples returned by Apollo

433
00:25:45,029 --> 00:25:42,009
astronauts have been investigated in

434
00:25:49,109 --> 00:25:45,039
detail thus far so a lot of work lies

435
00:25:51,479 --> 00:25:49,119
ahead deciphering the complex stretches

436
00:25:54,930 --> 00:25:51,489
and core samples is slow and tedious

437
00:25:56,820 --> 00:25:54,940
work but it is here that extremely

438
00:25:59,389 --> 00:25:56,830

complicated measurements are now being

439
00:26:02,909 --> 00:25:59,399
made measurements aimed at uncovering

440
00:26:05,909 --> 00:26:02,919
facts about the moon's origin its first

441
00:26:17,910 --> 00:26:05,919
100 million years its volcanic history

442
00:26:23,310 --> 00:26:20,850
when will we return to the moon no one

443
00:26:27,840 --> 00:26:23,320
can say for sure but certainly it has a

444
00:26:30,540 --> 00:26:27,850
role to play in the future for a science

445
00:26:32,790 --> 00:26:30,550
colony its location the lack of a

446
00:26:36,720 --> 00:26:32,800
distorting atmosphere make it a natural

447
00:26:38,970 --> 00:26:36,730
choice as a staging base the moon may

448
00:26:42,780 --> 00:26:38,980
someday launch exploratory missions to

449
00:26:45,000 --> 00:26:42,790
the planets and beyond the moon is also

450
00:26:46,880 --> 00:26:45,010
a potential mining site for extraction

451
00:26:51,720 --> 00:26:46,890
of its abundant storehouse of metals

452
00:26:53,400 --> 00:26:51,730
aluminum titanium calcium iron raw

453
00:26:56,840 --> 00:26:53,410
materials that could be used for

454
00:27:00,330 --> 00:26:56,850
building large-scale structures in space

455
00:27:02,820 --> 00:27:00,340
today after 10 years of lunar and

456
00:27:09,060 --> 00:27:02,830
planetary investigations interest and

457
00:27:10,860 --> 00:27:09,070
momentum continued to grow the lessons

458
00:27:13,490 --> 00:27:10,870
learned from the moon are being applied

459
00:27:20,030 --> 00:27:13,500
to the earth and to the other planets

460
00:27:26,190 --> 00:27:22,860
the process is observed on these planets

461
00:27:31,860 --> 00:27:26,200
are as strange as ever but no longer are

462
00:27:33,720 --> 00:27:31,870
they mysterious scientists see them as

463
00:27:37,230 --> 00:27:33,730

extensions of patterns which are now

464
00:27:39,000 --> 00:27:37,240
familiar and in time they will

465
00:27:41,850 --> 00:27:39,010
understand their structure their

466
00:27:45,210 --> 00:27:41,860
evolution how they relate to earth and

467
00:27:49,710 --> 00:27:45,220
eventually how this solar system of ours

468
00:27:51,640 --> 00:27:49,720
came to be Apollo was much more than a

469
00:27:54,300 --> 00:27:51,650
triumph of Technology

470
00:27:56,620 --> 00:27:54,310
like Columbus voyage to the New World

471
00:27:59,410 --> 00:27:56,630
the Wright brothers flights at Kitty

472
00:28:01,600 --> 00:27:59,420
Hawk the Apollo missions to the moon

473
00:28:06,490 --> 00:28:01,610
mark a major turning point in human