

1	01:00:04:18	01:00:08:00	Annenberg Media
2	01:00:08:02	01:01:01:28	§
3	01:01:02:00	01:01:04:27	<i>THE GREEKS BELIEVED</i>
4	01:01:04:29	01:01:07:27	<i>THAT THE FUMES FROM VOLCANOES</i>
5	01:01:07:29	01:01:10:16	<i>WERE THE FIERY</i>
6	01:01:13:04	01:01:14:17	<i>BREATH OF A MONSTER,</i>
7	01:01:14:19	01:01:17:17	<i>IMPRISONED BY ZEUS</i>
8	01:01:17:19	01:01:19:02	<i>BENEATH A MOUNTAIN.</i>
9	01:01:19:04	01:01:21:01	<i>THE ROMANS WERE CONVINCED</i>
10	01:01:23:26	01:01:25:10	<i>THAT SUCH ERUPTIONS</i>
11	01:01:25:12	01:01:28:09	<i>WERE THE WORK OF VULCAN,</i>
12	01:01:28:11	01:01:31:14	<i>BLACKSMITH TO THE GODS,</i>
13	01:01:37:06	01:01:39:04	<i>BUSY AT</i>
14	01:01:39:06	01:01:41:04	<i>HIS PERSONAL FORGE.</i>
15	01:01:41:06	01:01:44:04	<i>DURING THE MIDDLE AGES,</i>
16	01:01:44:06	01:01:48:03	<i>VOLCANOES WERE FEARED</i>
17	01:01:48:05	01:01:49:22	<i>AS PASSAGEWAYS TO HELL,</i>
18	01:01:49:24	01:01:51:13	<i>A SULFUROUS INFERNO</i>
19	01:01:51:15	01:01:53:27	<i>FOR THE DAMNED.</i>
20	01:01:53:29	01:01:55:11	<i>OUR MODERN SPACECRAFT</i>
21	01:01:55:13	01:01:57:27	<i>HAVE REVEALED</i>
22	01:01:57:29	01:02:00:11	<i>THAT IF VOLCANOES</i>
23	01:02:00:13	01:02:01:25	<i>ARE HELL,</i>
24	01:02:01:27	01:02:03:25	<i>THEN THERE IS NOT</i>
25	01:02:03:27	01:02:06:11	<i>ONLY HELL ON EARTH.</i>
26	01:02:06:13	01:02:09:10	<i>IT EXISTS IN MANY OTHER</i>
27	01:02:09:12	01:02:11:14	<i>PARTS OF THE SOLAR SYSTEM.</i>
28	01:02:13:27	01:02:16:24	<i>IN 1988,</i>
29	01:02:16:26	01:02:18:10	<i>THE VOYAGER SPACE PROBE</i>
30	01:02:18:12	01:02:22:26	<i>STARTLED SCIENTISTS</i>
31	01:02:22:28	01:02:25:10	<i>WHEN IT SHOWED</i>
32	01:02:25:12	01:02:28:10	<i>JUPITER'S MOON IO</i>
33	01:02:28:12	01:02:30:10	<i>BELCHING VOLCANIC SULFUR</i>
34	01:02:30:12	01:02:33:09	<i>HUNDREDS OF KILOMETERS</i>
			<i>ABOVE THE SURFACE.</i>
			<i>NUMEROUS VOLCANOES HAVE</i>
			<i>ALSO BEEN OBSERVED</i>
			<i>ON THE PLANET VENUS,</i>
			<i>AS WELL AS ON MARS,</i>
			<i>WHERE THE LARGEST VOLCANO,</i>
			<i>OLYMPUS MONS,</i>
			<i>IS THREE TIMES THE HEIGHT</i>
			<i>OF MOUNT EVEREST</i>
			<i>AND 600 KILOMETERS ACROSS.</i>
			<i>VOLCANIC GASSES HAVE</i>
			<i>CONTRIBUTED TO THE ATMOSPHERES</i>
			<i>OF THESE OTHER WORLDS,</i>
			<i>JUST AS THEY HAVE PROVIDED</i>
			<i>THE AIR WE BREATHE ON EARTH,</i>
			<i>PRODUCED WATER</i>
			<i>FOR STREAMS AND OCEANS,</i>
			<i>AND HELPED CREATE CONDITIONS</i>
			<i>SUITABLE FOR LIFE.</i>
			<i>THEY ALSO SERVE AS CLUES</i>
			<i>ABOUT WHAT IS GOING ON</i>
			<i>INSIDE OUR PLANET.</i>

35 01:02:35:12 01:02:36:25 VOLCANOES ARE PROOF  
 36 01:02:36:27 01:02:39:24 THAT THE EARTH'S INTERIOR  
 IS VERY HOT,  
 37 01:02:39:26 01:02:41:26 HOT ENOUGH TO MELT ROCK.  
 38 01:02:41:28 01:02:44:25 THIS MOLTEN ROCK,  
 CALLED MAGMA, IS LESS DENSE  
 39 01:02:44:27 01:02:46:25 THAN THE SURROUNDING  
 UNMELTED ROCK.  
 40 01:02:46:27 01:02:48:00 IT RISES BUOYANTLY,  
 41 01:02:48:02 01:02:50:10 JUST AS CURRENTS  
 OF HOT AIR  
 42 01:02:50:12 01:02:52:21 RISE FROM THE SURFACE  
 OF THE EARTH,  
 43 01:02:52:23 01:02:54:24 WHERE THE MAGMA REACHES  
 THE EARTH'S SURFACE,  
 44 01:02:54:26 01:02:56:00 VOLCANOES ERUPT.  
 45 01:02:56:02 01:02:58:00 DIFFERENT VOLCANO TYPES  
 CAN ERUPT  
 46 01:02:58:02 01:02:59:14 IN VERY DIFFERENT WAYS.  
 47 01:02:59:16 01:03:00:25 IN SOME ERUPTIONS,  
 48 01:03:00:27 01:03:03:09 MAGMA POURS ONTO  
 THE EARTH'S SURFACE  
 49 01:03:03:11 01:03:06:08 IN RIVERS OF MOLTEN  
 ROCK CALLED LAVA FLOWS.  
 50 01:03:06:10 01:03:08:23 IN OTHERS, HIGH GAS  
 PRESSURES UNDERGROUND  
 51 01:03:08:25 01:03:11:07 CAUSE THE VOLCANO  
 TO ERUPT EXPLOSIVELY.  
 52 01:03:11:09 01:03:13:22 THE MAGMA IS SPRAYED  
 INTO THE AIR  
 53 01:03:13:24 01:03:16:23 AS A CLOUD OF VERY  
 SMALL, HOT PARTICLES  
 54 01:03:16:25 01:03:18:09 CALLED VOLCANIC ASH.  
 55 01:03:18:11 01:03:19:23 THIS FINE ROCK POWDER  
 56 01:03:19:25 01:03:23:08 CAN REMAIN ALOFT  
 IN THE ATMOSPHERE FOR DAYS  
 57 01:03:23:10 01:03:25:08 AND TRAVEL THOUSANDS  
 OF KILOMETERS  
 58 01:03:25:10 01:03:28:07 BEFORE FINALLY SETTLING  
 TO THE EARTH'S SURFACE.  
 59 01:03:28:09 01:03:30:24 SOMETIMES VOLCANIC ASH  
 CAN REMAIN SUSPENDED  
 60 01:03:30:26 01:03:32:18 IN THE ATMOSPHERE  
 FOR MONTHS,  
 61 01:03:32:20 01:03:35:02 BLOCKING OUT SUNLIGHT  
 AND AFFECTING GLOBAL WEATHER.  
 62 01:03:35:04 01:03:37:23 VOLCANOES NOT ONLY ERUPT  
 IN DIFFERENT WAYS,  
 63 01:03:37:25 01:03:39:08 BUT THEY'RE ALSO FOUND  
 64 01:03:39:10 01:03:42:08 IN A WIDE VARIETY  
 OF GEOLOGIC ENVIRONMENTS.  
 65 01:03:42:10 01:03:45:07 THERE ARE ABOUT 500  
 KNOWN ACTIVE VOLCANOES  
 66 01:03:45:09 01:03:46:15 ON DRY LAND.  
 67 01:03:46:17 01:03:48:22 MOST VOLCANIC ACTIVITY  
 OCCURS IN PLACES

68 01:03:48:24 01:03:50:08 HIDDEN FROM VIEW.  
69 01:03:50:10 01:03:52:18 THERE ARE PROBABLY SEVERAL  
THOUSAND ACTIVE VOLCANOES  
70 01:03:52:20 01:03:54:03 ON THE OCEAN FLOOR.  
71 01:03:54:05 01:03:57:04 MOST OF THESE LIE ASTRIDE  
MID-OCEAN RIDGES  
72 01:03:57:06 01:03:59:02 WHERE EARTH'S  
FORMING NEW CRUST.  
73 01:04:01:03 01:04:03:02 *MOST UNDERSEA  
VOLCANOES LIE*  
74 01:04:03:04 01:04:05:25 *ALONG DIVERGENT  
PLATE BOUNDARIES.*  
75 01:04:05:27 01:04:07:09 *HERE,  
RUNNY BASALTIC LAVA,*  
76 01:04:07:11 01:04:09:24 *AS HOT AS*  
*1,200 DEGREES CENTIGRADE,*  
77 01:04:09:26 01:04:11:09 *POURS QUIETLY  
THROUGH FISSURES,*  
78 01:04:11:11 01:04:14:09 *MUCH OF IT COOLING  
IN THE DARK WATER*  
79 01:04:14:11 01:04:17:10 *TO FORM FLOWS  
OF BULBOUS ROCK*  
80 01:04:17:12 01:04:18:28 *CALLED PILLOW LAVA.*  
81 01:04:19:00 01:04:20:14 *OTHER OCEANIC VOLCANOES,*  
82 01:04:20:16 01:04:23:15 *SUCH AS THOSE  
OF THE HAWAIIAN CHAIN,*  
83 01:04:23:17 01:04:27:00 *DO NOT LIE ON  
DIVERGENT PLATE BOUNDARIES.*  
84 01:04:28:05 01:04:30:01 THE HAWAIIAN  
VOLCANIC CHAIN OCCURS  
85 01:04:30:03 01:04:33:01 IN THE MIDDLE  
OF THE PACIFIC PLATE  
86 01:04:33:03 01:04:35:17 FAR REMOVED  
FROM ANY PLATE BOUNDARY.  
87 01:04:35:19 01:04:39:02 THE BEST HYPOTHESIS THAT  
HAS BEEN INVOKED SO FAR  
88 01:04:39:04 01:04:40:16 TO EXPLAIN THAT  
89 01:04:40:18 01:04:43:07 IS CALLED THE "HAWAIIAN  
HOT SPOT" HYPOTHESIS.  
90 01:04:43:09 01:04:46:06 AND WHAT THAT ENTAILS  
IS A HOT SPOT,  
91 01:04:46:08 01:04:47:21 A ZONE OF MELTING,  
92 01:04:47:23 01:04:49:06 DEEP IN THE MANTLE,  
93 01:04:49:08 01:04:51:21 OVER WHICH  
THE PACIFIC PLATE RIDES  
94 01:04:51:23 01:04:55:07 TO THE NORTHWEST AS  
PART OF THE PLATE MOTIONS.  
95 01:04:55:09 01:04:58:22 AND THAT THIS HEAT SOURCE  
THEN--OR HOT SPOT--  
96 01:04:58:24 01:05:01:19 ACTUALLY LOCALLY MELTS  
THE OVERRIDING SOLID ROCK  
97 01:05:01:21 01:05:04:19 TO FORM THE BASALTIC  
MAGMAS WHICH THEN ERUPT.  
98 01:05:04:21 01:05:07:19 THEN, AS THE PLATE  
CONTINUES TO MOVE,  
99 01:05:07:21 01:05:09:03 THE VOLCANO THAT FORMED

100 01:05:09:05 01:05:12:15 IS TRANSPORTED  
TO THE NORTHWEST

101 01:05:12:17 01:05:13:29 AND ULTIMATELY GETS SEVERED

102 01:05:14:01 01:05:15:29 FROM THE FEEDING  
MAGMA SOURCE

103 01:05:16:01 01:05:17:22 AND BECOMES EXTINCT.

104 01:05:17:24 01:05:19:24 HOWEVER, THEN OVER  
THE SAME PLACE

105 01:05:19:26 01:05:21:12 A NEW VOLCANO FORMS

106 01:05:21:14 01:05:23:12 AS MORE MAGMA  
IS MELTED,

107 01:05:23:14 01:05:25:12 AND A NEW ISLAND FORMS.

108 01:05:25:14 01:05:27:12 THE CHAIN  
OF HAWAIIAN ISLANDS

109 01:05:27:14 01:05:29:03 SHOW AN AGE PROGRESSION

110 01:05:29:05 01:05:30:11 GOING FROM THE SOUTHEAST,

111 01:05:30:13 01:05:32:22 WHICH IS CURRENTLY  
OVER THE HOT SPOT,

112 01:05:32:24 01:05:34:19 GOING TO THE NORTHWEST.

113 01:05:34:21 01:05:37:19 *LIKE VOLCANOES  
AT DIVERGENT BOUNDARIES,*

114 01:05:37:21 01:05:39:19 *OCEANIC HOT SPOT  
VOLCANOES ERUPT*

115 01:05:39:21 01:05:43:09 *PREDOMINANTLY VERY HOT,  
BASALTIC LAVA.*

116 01:05:43:11 01:05:45:09 *FLOW AFTER FLOW  
PILES UP,*

117 01:05:45:11 01:05:48:03 *BUILDING VAST BROAD  
MOUNTAINS,*

118 01:05:48:05 01:05:50:25 *KNOWN AS SHIELD VOLCANOES.*

119 01:05:52:01 01:05:53:14 [TILLING]  
IN GENERAL,

120 01:05:53:16 01:05:56:13 THE VOLCANOES FORMED BY  
VERY LOW VISCOSITY MAGMAS

121 01:05:56:15 01:05:58:25 TEND TO BE VERY BROAD,

122 01:05:58:27 01:06:01:08 CONVEX, VERY BROAD,  
SHIELD-LIKE VOLCANOES

123 01:06:01:10 01:06:05:21 THAT, IN FACT, ARE  
CALLED SHIELD VOLCANOES.

124 01:06:05:23 01:06:07:16 WHEN THE LAVA HAS ERUPTED,

125 01:06:07:18 01:06:08:28 BECAUSE IT'S SO FLUID,

126 01:06:09:00 01:06:11:25 IT CAN SPREAD OUT  
OVER LONG DISTANCES

127 01:06:11:27 01:06:13:05 ON VERY LOW SLOPES.

128 01:06:13:07 01:06:15:17 SO, AS A CONSEQUENCE,  
YOU GET LAVA FLOWS

129 01:06:15:19 01:06:18:01 TRAVELING FOR  
10, 20, 30 KILOMETERS.

130 01:06:20:15 01:06:22:13 *MANY PEOPLE  
THINK OF A VOLCANO*

131 01:06:22:15 01:06:25:12 *AS ERUPTING ONLY FROM  
A CRATER AT ITS SUMMIT.*

132 01:06:25:14 01:06:29:17 *BUT, IN FACT, THIS IS  
NOT TRUE OF MOST VOLCANOES.*

133 01:06:29:19 01:06:31:17 *ON A HAWAIIAN  
SHIELD VOLCANO,*

134 01:06:31:19 01:06:34:16 LAVA CAN ISSUE NOT ONLY  
FROM SUMMIT VENTS,  
135 01:06:34:18 01:06:37:17 BUT FROM THE FLANKS,  
THROUGH LONG SYSTEMS  
136 01:06:37:19 01:06:40:16 OF FISSURES KNOWN  
AS RIFT ZONES.  
137 01:06:43:04 01:06:44:21 GRAVITATIONAL STRESSES  
138 01:06:44:23 01:06:47:23 ACTING ON THE SIDE  
OF THE SHIELD,  
139 01:06:47:25 01:06:50:02 TOGETHER WITH THE PRESSURE  
FROM INTRUDING MAGMA,  
140 01:06:50:04 01:06:52:07 CAUSE RIFT ZONES TO FORM.  
141 01:06:53:29 01:06:57:03 THIS RIFT ZONE  
ON KILAUEA VOLCANO  
142 01:06:57:05 01:07:00:26 IS OVER  
50 KILOMETERS LONG.  
143 01:07:00:28 01:07:02:20 SOME VOLCANOES AT SEA,  
144 01:07:02:22 01:07:04:20 TOGETHER WITH  
THE GREAT MAJORITY  
145 01:07:04:22 01:07:06:21 OF VOLCANOES ON DRY LAND,  
146 01:07:06:23 01:07:09:06 LIE ALONG  
CONVERGENT PLATE BOUNDARIES,  
147 01:07:09:08 01:07:12:10 SUCH AS THOSE THAT  
ENCIRCLE THE PACIFIC OCEAN.  
148 01:07:15:17 01:07:18:24 VOLCANOES IN  
CONVERGENT PLATE SETTINGS  
149 01:07:18:26 01:07:21:10 TEND TO ERUPT  
MORE EXPLOSIVELY  
150 01:07:21:12 01:07:23:10 THAN THOSE AT HOT SPOTS  
151 01:07:23:12 01:07:24:27 AND ALONG  
DIVERGENT BOUNDARIES.  
152 01:07:24:29 01:07:27:14 THEY ARE CALLED  
COMPOSITE VOLCANOES  
153 01:07:27:16 01:07:29:15 BECAUSE THEY ARE MADE OF  
154 01:07:29:17 01:07:31:16 ALTERNATING LAYERS  
OF LAVA FLOWS  
155 01:07:31:18 01:07:34:06 AND EXPLOSIVELY  
ERUPTED FRAGMENTS.  
156 01:07:36:17 01:07:38:15 ALL VOLCANOES ERUPT GAS,  
157 01:07:38:17 01:07:41:15 WHICH CONTRIBUTES  
TO VOLCANIC EXPLOSIVENESS.  
158 01:07:41:17 01:07:45:10 THE MOST COMMON SUBSTANCES  
IN VOLCANIC GAS--  
159 01:07:45:12 01:07:47:05 WATER VAPOR,  
CARBON DIOXIDE,  
160 01:07:47:07 01:07:48:25 SULFUR, AND NITROGEN--  
161 01:07:48:27 01:07:50:24 ARE ALSO FOUND IN THE AIR  
162 01:07:50:26 01:07:52:09 AND IN THE OCEANS.  
163 01:07:52:11 01:07:53:25 EVIDENCE OF VOLCANIC GAS  
164 01:07:53:27 01:07:58:24 CAN EVEN BE FOUND LOCKED  
WITHIN HARDENED LAVA.  
165 01:07:58:26 01:08:01:08 THIS BLACK VOLCANIC ROCK  
IS BASALT,  
166 01:08:01:10 01:08:04:02 IT'S THE PRINCIPAL TYPE  
OF LAVA FOUND  
167 01:08:04:04 01:08:05:17 IN SHIELD VOLCANOES.

168 01:08:05:19 01:08:07:13 LIKE OTHER TYPES  
OF VOLCANIC ROCK,  
169 01:08:07:15 01:08:10:14 BASALT FORMS WHEN  
LAVA COOLS AND CRYSTALLIZES  
170 01:08:10:16 01:08:12:08 FOLLOWING  
A VOLCANIC ERUPTION.  
171 01:08:12:10 01:08:13:24 WHEN AN ERUPTION OCCURS,  
172 01:08:13:26 01:08:16:12 THERE'S A SUDDEN DROP  
IN PRESSURE,  
173 01:08:16:14 01:08:18:13 WHICH CAUSES  
BUBBLES OF GAS  
174 01:08:18:15 01:08:20:13 TO SPONTANEOUSLY FORM  
IN THE LAVA.  
175 01:08:20:15 01:08:24:01 THIS SAME PROCESS OCCURS  
OPENING A BOTTLE OF SODA.  
176 01:08:28:08 01:08:30:07 THESE HOLES IN THE BASALT  
177 01:08:30:09 01:08:32:05 WERE CREATED  
BY GAS BUBBLES  
178 01:08:32:07 01:08:35:05 THAT FORMED IN THE LAVA  
WHEN IT ERUPTED.  
179 01:08:35:07 01:08:38:05 *ALONG WITH THE IMPACT  
OF GAS CONTENT,*  
180 01:08:38:07 01:08:40:04 *THE EXPLOSIVENESS  
OF AN ERUPTION*  
181 01:08:40:06 01:08:42:13 *IS ALSO INFLUENCED  
BY THE TEMPERATURE*  
182 01:08:42:15 01:08:44:14 *AND CHEMICAL COMPOSITION  
OF ITS MAGMA.*  
183 01:08:44:16 01:08:46:13 *MAGMA, RICH IN SILICA,*  
184 01:08:46:15 01:08:48:28 *IS TYPICALLY COOLER  
AND MORE VISCOUS*  
185 01:08:49:00 01:08:52:13 *THAN MAGMA WITH  
A LOWER SILICA CONTENT.*  
186 01:08:52:15 01:08:53:27 *THIS RESULTS IN ERUPTIONS*  
187 01:08:53:29 01:08:57:07 *THAT ARE  
EXTREMELY EXPLOSIVE.*  
188 01:08:57:09 01:09:00:07 WHY IS THE ERUPTION  
OF A COMPOSITE VOLCANO  
189 01:09:00:09 01:09:01:20 SO VIOLENT AND EXPLOSIVE?  
190 01:09:01:22 01:09:04:20 THE ANSWER LIES  
IN THE ANDESITIC LAVAS  
191 01:09:04:22 01:09:06:26 OF WHICH THESE VOLCANOES  
ARE COMPOSED.  
192 01:09:06:28 01:09:08:11 ANDESITE CONTAINS  
MORE SILICA  
193 01:09:08:13 01:09:09:26 THAN BASALT DOES,  
194 01:09:09:28 01:09:12:25 SO IT CRYSTALLIZES  
AT A LOWER TEMPERATURE,  
195 01:09:12:27 01:09:14:25 CREATING  
A MORE VISCOUS LAVA.  
196 01:09:14:27 01:09:17:27 CRYSTALS WILL OFTEN FORM  
IN AN ANDESITE MAGMA  
197 01:09:17:29 01:09:20:08 BEFORE AN ERUPTION,  
THICKENING IT EVEN FURTHER.  
198 01:09:20:10 01:09:23:10 HIGH VISCOSITY TRAPS GASES  
DISSOLVED WITHIN THE MAGMA

199 01:09:23:12 01:09:26:11 AND PREVENTS THEM  
FROM ESCAPING EASILY.

200 01:09:26:13 01:09:29:10 DURING THE INITIAL STAGES  
OF THE ERUPTION,

201 01:09:29:12 01:09:31:26 GAS BUBBLES CANNOT BREAK  
THROUGH THE THICK LAVA

202 01:09:31:28 01:09:33:12 UNTIL PRESSURES  
WITHIN THEM

203 01:09:33:14 01:09:34:27 REACH EXPLOSIVE  
PROPORTIONS.

204 01:09:34:29 01:09:38:13 WE KNOW WHAT PENT-UP  
GAS PRESSURES CAN DO.

205 01:09:39:16 01:09:41:13 THE BLAST OF THE ERUPTION

206 01:09:41:15 01:09:43:25 SPRAYS FINE DROPLETS  
OF LAVA INTO THE AIR,

207 01:09:43:27 01:09:45:25 FORMING CLOUDS  
OF VOLCANIC ASH.

208 01:09:45:27 01:09:49:10 AND THE ESCAPING GAS  
WHIPS SOME OF THE LAVA

209 01:09:49:12 01:09:51:18 INTO A FOAM CALLED PUMICE.

210 01:09:51:20 01:09:54:19 *PUMICE IS A SPECIAL TYPE  
OF VOLCANIC ROCK*

211 01:09:54:21 01:09:57:03 *FORMED FROM THE ERUPTION  
OF VISCOUS,*

212 01:09:57:05 01:10:00:15 *HIGHLY GASEOUS MAGMA.*

213 01:10:00:17 01:10:02:15 *IT HAS  
A FROTHY CONSISTENCY*

214 01:10:02:17 01:10:04:27 *AND IS SO FULL  
OF AIR POCKETS*

215 01:10:04:29 01:10:08:12 *THAT IT CAN FLOAT  
IN WATER.*

216 01:10:08:14 01:10:10:26 *VISCOSITY  
NOT ONLY INFLUENCES*

217 01:10:10:28 01:10:13:11 *THE EXPLOSIVENESS  
OF AN ERUPTION,*

218 01:10:13:13 01:10:15:29 *BUT THE CHARACTER  
OF ITS LAVA AS WELL.*

219 01:10:16:01 01:10:19:14 *THE HAWAIIANS HAVE WORDS  
FOR THE TWO MAIN TYPES*

220 01:10:19:16 01:10:22:13 *OF LAVA SURFACE THAT ARE  
INFLUENCED BY VISCOSITY--*

221 01:10:22:15 01:10:24:28 *RUNNY LAVA, WHICH  
CONTAINS DISSOLVED GASES,*

222 01:10:25:00 01:10:26:28 *FORMS A SMOOTH,  
BILLOWY SURFACE*

223 01:10:27:00 01:10:31:23 *CALLED PAHOEHOE,  
LITERALLY "ROPY."*

224 01:10:33:19 01:10:36:27 *DEGASSED LAVA IS STIFFER  
TEARING APART ITS CRUST*

225 01:10:36:29 01:10:38:27 *THROUGH  
ITS OWN FORWARD MOTION.*

226 01:10:38:29 01:10:41:19 *THIS FORMS  
A ROUGH SURFACE*

227 01:10:41:21 01:10:44:17 *THE HAWAIIANS CALL A'A,*

228 01:10:44:19 01:10:46:02 *WHICH, TRANSLATED MEANS--*

229 01:10:46:04 01:10:48:09 *"A PAINFUL SURFACE*

FOR WALKING."

230 01:10:49:26 01:10:54:12 ACTIVE PAHOEHOE FLOWS  
DEVELOP LAVA TUBES.

231 01:10:54:14 01:10:58:04 AS THE LAVA SLOWLY COOLS  
ALONG ITS MARGINS,

232 01:10:58:06 01:11:00:25 IT SEALS ITSELF  
IN A NARROW CHANNEL,

233 01:11:00:27 01:11:02:09 WHICH MAY CRUST OVER.

234 01:11:02:11 01:11:03:24 INSULATED IN A TUBE,

235 01:11:03:26 01:11:06:09 THE MOLTEN LAVA  
LOSES LITTLE HEAT.

236 01:11:06:11 01:11:08:08 THIS ALLOWS IT  
TO TRAVEL FURTHER

237 01:11:08:10 01:11:09:24 THAN IT COULD OTHERWISE,

238 01:11:09:26 01:11:12:09 WHICH IS ONE REASON  
SHIELD VOLCANOES

239 01:11:12:11 01:11:14:24 ARE SO BROAD  
AND GENTLY SLOPING.

240 01:11:14:26 01:11:18:24 MORE EXPLOSIVE VOLCANOES  
BUILD STEEP CONES

241 01:11:18:26 01:11:22:09 BECAUSE THE LAVA IS STIFFER  
AND CANNOT SPREAD AS FAR,

242 01:11:22:11 01:11:23:24 AND BECAUSE  
EXPLOSIVE DEBRIS

243 01:11:23:26 01:11:27:14 SIMPLY PILES UP  
AROUND THE CENTRAL VENT.

244 01:11:27:16 01:11:28:29 SOME VOLCANIC CONES

245 01:11:29:01 01:11:31:13 ARE MADE UP ENTIRELY  
OF FRAGMENTS.

246 01:11:31:15 01:11:33:18 CINDER CONES ARE  
GOOD EXAMPLES.

247 01:11:35:20 01:11:38:18 CINDER CONES, LIKE  
THE ONE BEHIND ME,

248 01:11:38:20 01:11:40:03 ARE VERY DIFFERENT

249 01:11:40:05 01:11:42:20 FROM COMPOSITE VOLCANOES  
OR SHIELD VOLCANOES.

250 01:11:42:22 01:11:44:05 THEY'RE SMALL  
IN COMPARISON,

251 01:11:44:07 01:11:47:19 AND THE FLANKS OF  
THE CONES ARE QUITE STEEP.

252 01:11:47:21 01:11:50:10 A CINDER CONE IS COMPOSED  
OF FRAGMENTS

253 01:11:50:12 01:11:52:05 OF VOLCANIC ROCK,  
CALLED CINDERS.

254 01:11:52:07 01:11:55:07 LIKE VOLCANIC ASH,  
CINDERS ARE DROPLETS OF LAVA

255 01:11:55:09 01:11:57:24 FORMED DURING  
AN EXPLOSIVE ERUPTION.

256 01:11:57:26 01:12:00:11 THE DROPS THAT  
FORM CINDERS, HOWEVER,

257 01:12:00:13 01:12:02:23 ARE MUCH LARGER  
THAN ASH PARTICLES,

258 01:12:02:25 01:12:04:07 INDICATING THAT  
THE EXPLOSION

259 01:12:04:09 01:12:05:23 WAS MUCH LESS POWERFUL

260 01:12:05:25 01:12:08:20 THAN THAT OF A TYPICAL



261 01:12:10:13 COMPOSITE VOLCANO.  
 01:12:12:28 VOLCANOES ARE,  
 262 01:12:13:00 01:12:14:28 FOR THE MOST PART,  
 ASSOCIATED WITH  
 263 01:12:15:00 01:12:18:12 CONVERGENT AND DIVERGENT  
 PLATE BOUNDARIES, OR  
 264 01:12:18:14 01:12:21:17 WELL-ESTABLISHED HOT SPOTS.  
 BUT THERE ARE SOME  
 265 01:12:24:25 01:12:26:22 INTRIGUING EXCEPTIONS.  
 VOLCANIC ACTIVITY  
 266 01:12:26:24 01:12:29:21 HAS OCCASIONALLY OCCURRED  
 FAR FROM THESE SETTINGS,  
 267 01:12:29:23 01:12:32:21 SUCH AS HERE  
 IN THE DESERT OF  
 268 01:12:32:23 01:12:36:06 SOUTHEASTERN CALIFORNIA.  
 WE'RE 700 KILOMETERS  
 269 01:12:36:08 01:12:38:06 FROM THE NEAREST  
 CONVERGENT PLATE  
 270 01:12:38:08 01:12:41:01 BOUNDARY  
 WHERE SUBDUCTION-RELATED  
 271 01:12:41:03 01:12:42:08 VOLCANO ACTIVITY  
 IS OCCURRING.  
 272 01:12:42:10 01:12:45:07 AND 200 OR 300 KILOMETERS  
 273 01:12:45:09 01:12:48:07 FROM THE NEAREST  
 DIVERGENT PLATE BOUNDARY,  
 274 01:12:48:09 01:12:52:14 YET, WE SIT NEAR THE TOP  
 OF A YOUNG CINDER CONE,  
 275 01:12:52:16 01:12:54:23 A VOLCANO  
 THAT'S BEEN ACTIVE  
 276 01:12:54:25 01:12:58:15 PROBABLY WITHIN THE PAST  
 FEW THOUSAND YEARS,  
 277 01:12:58:17 01:13:00:07 FAR FROM  
 A PLATE BOUNDARY.  
 278 01:13:00:09 01:13:01:16 THAT'S  
 CERTAINLY RIGHT.  
 279 01:13:01:18 01:13:03:13 MOST VOLCANOES  
 IN THE WORLD  
 280 01:13:03:15 01:13:05:06 ARE ALONG  
 THE PLATE BOUNDARIES.  
 281 01:13:05:08 01:13:07:20 BUT THROUGHOUT THE WORLD,  
 THERE ARE MANY PLACES  
 282 01:13:07:22 01:13:09:20 WHERE THE CRUST  
 IS BEING STRETCHED  
 283 01:13:09:22 01:13:12:04 BY TENSIONAL FORCES AND  
 FRACTURES ARE OPENING UP.  
 284 01:13:12:06 01:13:15:06 I THINK THIS STILL  
 REFLECTS PLATE TECTONICS  
 285 01:13:15:08 01:13:17:21 BECAUSE THE CRUST  
 IS BEING THINNED,  
 286 01:13:17:23 01:13:21:05 BEING PULLED APART,  
 AND UNDER THAT TENSION,  
 287 01:13:21:07 01:13:23:06 THE CRUST  
 ACTUALLY FRACTURES.  
 288 01:13:23:08 01:13:24:26 WITH THAT SITUATION,  
 289 01:13:24:28 01:13:27:05 THE PRESSURE IS RELIEVED  
 ON THE SYSTEM,

290 01:13:27:07 01:13:29:05 SO THE MAGMA CAN RISE UP.  
 291 01:13:29:07 01:13:32:06 SO WHEREVER IN THIS REGION  
 YOU HAVE LOCALIZED MAGMA,  
 292 01:13:32:08 01:13:34:21 DUE TO WHATEVER  
 HEAT SOURCES EXIST,  
 293 01:13:34:23 01:13:36:15 THE MAGMA WILL COME THROUGH  
 294 01:13:36:17 01:13:39:04 AND ERUPT AND  
 FORM A CINDER CONE.  
 295 01:13:39:06 01:13:41:05 *BELTS OF VOLCANOES*  
*HAVE GROWN, SHIFTED,*  
 296 01:13:41:07 01:13:44:05 *AND DIED WITH CHANGES*  
*IN PLATE BOUNDARIES.*  
 297 01:13:44:07 01:13:48:06 *THE HISTORY OF INDIVIDUAL*  
*VOLCANOES THEMSELVES*  
 298 01:13:48:08 01:13:51:05 *CAN BE QUITE COMPLEX.*  
 299 01:13:51:07 01:13:53:20 A VOLCANO CAN LOOK  
 VERY DIFFERENT  
 300 01:13:53:22 01:13:55:20 AT DIFFERENT STAGES  
 IN ITS DEVELOPMENT.  
 301 01:13:55:22 01:13:58:05 HERE AT PANUM CRATER,  
 FOR EXAMPLE,  
 302 01:13:58:07 01:14:01:03 THE INITIAL ERUPTIONS  
 WERE GAS-CHARGED EXPLOSIONS.  
 303 01:14:01:05 01:14:02:28 THEY PRODUCED  
 THIS SHALLOW CRATER  
 304 01:14:03:00 01:14:06:02 SURROUNDED BY THE RIM  
 OF PUMICE I'M STANDING ON.  
 305 01:14:06:04 01:14:08:04 HAVING LOST  
 MOST OF ITS GASES,  
 306 01:14:08:06 01:14:10:04 THE REMAINING MAGMA  
 ROSE SLOWLY  
 307 01:14:10:06 01:14:12:18 OUT OF THE VENT  
 IN THE NEXT ERUPTION.  
 308 01:14:12:20 01:14:14:26 THIS MAGMA PLUGGED THE VENT  
 BY FORMING THIS DOME  
 309 01:14:14:28 01:14:16:11 COMPOSED OF VOLCANIC GLASS.  
 310 01:14:16:13 01:14:19:17 THIS GLASS,  
 KNOWN AS OBSIDIAN,  
 311 01:14:19:19 01:14:22:04 IS THE PRODUCT OF  
 AN EXTREMELY VISCOUS MAGMA.  
 312 01:14:22:06 01:14:25:22 IT'S COMPOSED  
 ALMOST ENTIRELY OF SILICA.  
 313 01:14:25:24 01:14:28:23 *VOLCANIC DOMES USUALLY*  
*FORM IN THE AFTERMATH*  
 314 01:14:28:25 01:14:31:08 *OF POWERFUL EXPLOSIONS*  
*AT COMPOSITE CONES,*  
 315 01:14:31:10 01:14:35:23 *SUCH AS AT*  
*MOUNT ST. HELENS IN 1980.*  
 316 01:14:38:13 01:14:40:12 *A DECADE*  
*AFTER THIS ERUPTION,*  
 317 01:14:40:14 01:14:42:25 *THE NEW DOME*  
*CONTINUED TO GROW*  
 318 01:14:42:27 01:14:44:27 *INSIDE*  
*THE VOLCANO'S CRATER.*  
 319 01:14:47:05 01:14:49:02 *ONE OF THE GREATEST HAZARDS*  
 320 01:14:49:04 01:14:51:18 *ASSOCIATED*

321 01:14:51:20 WITH EXPLOSIVE VOLCANISM  
 01:14:54:03 IS DENSE CLOUDS  
 OF HOT ASH  
 322 01:14:54:05 01:14:55:18 WHICH ROAR DOWN  
 VOLCANIC SLOPES  
 323 01:14:55:20 01:14:57:12 INTO LOW-LYING AREAS  
 324 01:14:57:14 01:15:01:01 SOMETIMES AT WELL OVER  
 100 KILOMETERS PER HOUR  
 325 01:15:04:18 01:15:07:01 IT IS CURRENTLY ESTIMATED  
 THAT VOLCANOES  
 326 01:15:07:03 01:15:08:21 POSE A POTENTIAL THREAT  
 327 01:15:08:23 01:15:12:22 TO MORE THAN HALF A BILLION  
 PEOPLE ACROSS THE GLOBE.  
 328 01:15:14:10 01:15:17:27 IN AN EFFORT TO LESSEN  
 THE DAMAGE FROM VOLCANOES,  
 329 01:15:17:29 01:15:19:27 GEOLOGISTS ARE REFINING  
 THEIR METHODS  
 330 01:15:19:29 01:15:22:00 OF FORECASTING ERUPTIONS.  
 331 01:15:23:20 01:15:25:09 PROBABLY  
 ALL VOLCANIC ERUPTIONS  
 332 01:15:25:11 01:15:27:24 ARE PRECEDED BY  
 AND ACCOMPANIED BY  
 333 01:15:27:26 01:15:29:25 MEASURABLE CHANGES  
 IN THE PHYSICAL  
 334 01:15:29:27 01:15:32:17 OR CHEMICAL STATE  
 OF THE VOLCANO.  
 335 01:15:32:19 01:15:35:16 AND ONE OF THE PRINCIPAL  
 MEANS OF MONITORING  
 336 01:15:35:18 01:15:37:16 OR MEASURING THE CHANGES--  
 337 01:15:37:18 01:15:41:01 AT LEAST THE PHYSICAL  
 CONFIGURATION OF A VOLCANO--  
 338 01:15:41:03 01:15:45:16 IS BY MEANS OF WHAT WE CALL  
 GROUND DEFORMATION STUDIES.  
 339 01:15:45:18 01:15:48:02 THIS SIMPLY  
 IS JUST A TERM  
 340 01:15:48:04 01:15:51:17 FOR MEASURING THE CHANGES  
 IN THE SHAPE OF THE VOLCANO.  
 341 01:15:51:19 01:15:53:16 MOST VOLCANOES  
 WILL SWELL UP  
 342 01:15:53:18 01:15:56:01 OR INFLATE PRIOR  
 TO AN ERUPTION,  
 343 01:15:56:03 01:15:59:01 AND THIS CAUSES  
 THE VOLCANO IN ITSELF--  
 344 01:15:59:03 01:16:00:28 THE SURFACE  
 OF THE VOLCANO--  
 345 01:16:01:00 01:16:02:14 TO BE UPLIFTED  
 346 01:16:02:16 01:16:05:25 AND THE SIDES TILTED OUT  
 AND BULGED OUTWARD.  
 347 01:16:05:27 01:16:10:15 THE OTHER MAJOR COMPONENT  
 IN TRACKING A VOLCANO  
 348 01:16:10:17 01:16:15:14 OR MONITORING A VOLCANO  
 IS THE SEISMIC MONITORING  
 349 01:16:15:16 01:16:18:28 OF EARTHQUAKES THAT OCCUR  
 BENEATH THE GROUND.  
 350 01:16:19:00 01:16:21:10 BECAUSE AS THE MOLTEN ROCK  
 351 01:16:21:12 01:16:23:25 FORCES ITS WAY TOWARD

352 01:16:23:27 THE SURFACE TO ERUPT,  
 01:16:27:15 IT MAKES ROOM FOR ITSELF,  
 353 01:16:27:17 01:16:29:22 AND MOVES UP HIGHER,  
 OR Laterally.  
 354 01:16:31:00 01:16:32:14 *IN RECENT YEARS,*  
 355 01:16:32:16 01:16:34:18 *SCIENTISTS HAVE BEEN*  
*INCREASINGLY SUCCESSFUL*  
 356 01:16:34:20 01:16:38:00 *IN FORECASTING MAJOR*  
*VOLCANIC ERUPTIONS.*  
 357 01:16:38:02 01:16:40:15 *DESPITE THESE ADVANCES,*  
*THERE'S STILL MUCH*  
 358 01:16:40:17 01:16:42:15 *TO BE LEARNED*  
*ABOUT VOLCANOES.*  
 359 01:16:42:17 01:16:45:29 *MANY VOLCANOES HAVE*  
*DISTINCTIVE BEHAVIOR.*  
 360 01:16:46:01 01:16:47:28 *OFTEN ERUPTIONS*  
*ARE TOO DANGEROUS*  
 361 01:16:48:00 01:16:50:18 *TO OBSERVE AT CLOSE RANGE.*  
 362 01:16:50:20 01:16:52:28 *AND SOME OF THE MOST*  
*IMPORTANT ERUPTIONS*  
 363 01:16:53:00 01:16:56:01 *OF OUR TIME HAVE BURST*  
*FORTH IN REMOTE REGIONS,*  
 364 01:16:56:03 01:16:58:14 *FAR FROM THE VIEW*  
*OF GEOLOGISTS.*  
 365 01:17:00:09 01:17:03:07 *ON THE AFTERNOON*  
*OF JUNE 1, 1912,*  
 366 01:17:03:09 01:17:04:22 *ONE SUCH ERUPTION BEGAN*  
 367 01:17:04:24 01:17:07:07 *IN THE VICINITY*  
*OF MOUNT KATMAI,*  
 368 01:17:07:09 01:17:09:23 *A VOLCANO IN*  
*THE ALASKA RANGE.*  
 369 01:17:09:25 01:17:12:12 *THE SKY TURNED*  
*OMINOUSLY BLACK*  
 370 01:17:12:14 01:17:15:28 *AS AN IMMENSE CLOUD*  
*OF ASH, PUMICE, AND GAS*  
 371 01:17:16:00 01:17:18:13 *BILLOWED UP*  
*FROM THE VOLCANO.*  
 372 01:17:18:15 01:17:21:12 *VOLCANIC ACTIVITY*  
*CONTINUED RELENTLESSLY*  
 373 01:17:21:14 01:17:23:11 *FOR THREE DAYS.*  
 374 01:17:23:13 01:17:25:12 *DESPITE SEVERAL ATTEMPTS*  
 375 01:17:25:14 01:17:27:27 *TO REACH*  
*THE SITE OF THE ERUPTION,*  
 376 01:17:27:29 01:17:30:28 *IT WASN'T UNTIL 1916,*  
*FOUR YEARS LATER,*  
 377 01:17:31:00 01:17:33:23 *THAT A NATIONAL*  
*GEOGRAPHIC EXPEDITION*  
 378 01:17:33:25 01:17:35:23 *LED BY ROBERT FISKE GRIGGS*  
 379 01:17:35:25 01:17:37:27 *REACHED THE SCENE.*  
 380 01:17:37:29 01:17:40:09 *AS THE EXPLORERS*  
*FIRST ENTERED THE VALLEY*  
 381 01:17:40:11 01:17:41:25 *NEAR KATMAI*  
 382 01:17:41:27 01:17:45:01 *THEY WERE STARTLED TO SEE*  
*WHAT APPEARED TO BE*  
 383 01:17:45:03 01:17:47:11 *THOUSANDS OF SMALL,*

384 01:17:47:13 01:17:50:13 *STEAMING VOLCANOES.*  
 385 01:17:50:15 01:17:53:21 *IN FACT, THESE*  
 386 01:17:53:23 01:17:55:07 *WERE NOT VOLCANOES AT ALL,*  
 387 01:17:55:09 01:17:57:11 *BUT GASEOUS STEAM VENTS,*  
 388 01:17:57:13 01:17:58:26 *KNOWN AS FUMARoles.*  
 389 01:17:58:28 01:18:01:17 *BEFORE THE ERUPTION,*  
 390 01:18:01:19 01:18:03:00 *THE VALLEY*  
 391 01:18:03:02 01:18:05:00 *HAD CONSISTED OF SWAMPS*  
 392 01:18:05:02 01:18:07:11 *AND MOIST WOODLANDS.*  
 393 01:18:07:13 01:18:11:03 *WHEN THE THICK LAYER*  
 394 01:18:11:05 01:18:12:18 *OF HOT ASH*  
 395 01:18:12:20 01:18:14:24 *BLANKETED THE GROUND,*  
 396 01:18:14:26 01:18:17:10 *MOISTURE BOILED AWAY*  
 397 01:18:17:12 01:18:18:10 *AS STEAM.*  
 398 01:18:18:12 01:18:20:09 *GRIGGS DUBBED*  
 399 01:18:20:11 01:18:22:06 *THIS SIMMERING LANDSCAPE,*  
 400 01:18:22:08 01:18:24:24 *"THE VALLEY*  
 401 01:18:24:26 01:18:28:25 *OF 10,000 SMOKES."*  
 402 01:18:28:27 01:18:32:24 *THE EXPEDITION DISCOVERED*  
 403 01:18:32:26 01:18:34:10 *THAT THE SUMMIT*  
 404 01:18:34:12 01:18:37:09 *OF MOUNT KATMAI*  
 405 01:18:37:11 01:18:39:26 *HAD COLLAPSED,*  
 406 01:18:39:28 01:18:42:10 *FORMING A VAST CRATER,*  
 407 01:18:42:12 01:18:45:25 *OR CALDERA.*  
 408 01:18:47:17 01:18:49:16 *BUT THERE WAS NO EVIDENCE*  
 409 01:18:49:18 01:18:52:25 *THE ERUPTION*  
 410 01:18:52:27 01:18:56:20 *HAD ORIGINATED HERE.*  
 411 01:18:56:22 01:18:58:17 *INSTEAD, MAGMA SEEMED*  
 412 01:18:58:19 01:19:00:02 *TO HAVE MOVED OUT*  
 413 01:19:00:04 01:19:03:12 *FROM UNDERNEATH THE SUMMIT*  
 414 01:19:03:14 01:19:06:23 *TO ESCAPE ELSEWHERE.*  
 415 01:19:06:23 01:19:09:11 *UNSUPPORTED,*  
 416 01:19:09:11 01:19:12:00 *THE MOUNTAINTOP FELL IN.*  
 417 01:19:12:00 01:19:15:00 *THE ACTUAL ERUPTION SITE*  
 418 01:19:15:00 01:19:18:00 *LAY AT THE BASE*  
 419 01:19:18:00 01:19:21:00 *OF THE MOUNTAIN.*  
 420 01:19:21:00 01:19:24:00 *A DOME OF LAVA*  
 421 01:19:24:00 01:19:27:00 *HAD OOZED UP*  
 422 01:19:27:00 01:19:30:00 *NEAR THE CENTER*  
 423 01:19:30:00 01:19:33:00 *OF THE SOURCE VENT.*  
 424 01:19:33:00 01:19:36:00 *THE EXPEDITION NAMED*  
 425 01:19:36:00 01:19:39:00 *THIS DOME "NOVARUPTA."*  
 426 01:19:39:00 01:19:42:00 *TODAY,*  
 427 01:19:42:00 01:19:45:00 *THE DOME HAS COOLED,*  
 428 01:19:45:00 01:19:48:00 *AND MOST OF THE FUMARoles*  
 429 01:19:48:00 01:19:51:00 *ARE COLD AND INACTIVE.*  
 430 01:19:51:00 01:19:54:00 *BUT KATMAI IS STILL*  
 431 01:19:54:00 01:19:57:00 *OF ENORMOUS INTEREST*  
 432 01:19:57:00 01:20:00:00 *TO GEOLOGISTS,*  
 433 01:20:00:00 01:20:03:00 *WHO MUST WITHSTAND*  
 434 01:20:03:00 01:20:06:00 *DIFFICULT*  
 435 01:20:06:00 01:20:09:00 *PHYSICAL CONDITIONS*  
 436 01:20:09:00 01:20:12:00 *AS THEY CARRY ON*  
 437 01:20:12:00 01:20:15:00 *THEIR RESEARCH.*  
 438 01:20:15:00 01:20:18:00 *FIELD WORK IS RATHER*  
 439 01:20:18:00 01:20:21:00 *CHALLENGING TO BEGIN WITH*

415 01:19:06:25 01:19:09:12 BECAUSE IT INVOLVES  
 416 01:19:09:14 01:19:12:08 A CERTAIN AMOUNT OF  
 PLANNING AND PHYSICAL STAMINA.  
 417 01:19:12:10 01:19:14:08 THIS IS  
 PARTICULARLY CHALLENGING  
 418 01:19:14:10 01:19:15:22 BECAUSE IT'S SO REMOTE.  
 419 01:19:15:24 01:19:18:25 WE'RE REALLY  
 ON OUR OWN HERE.  
 420 01:19:18:27 01:19:20:24 THE WEATHER IS SO FIERCE,  
 421 01:19:20:26 01:19:25:23 AND THINGS LIKE--  
 THERE ARE OTHER ASPECTS  
 422 01:19:25:25 01:19:28:23 SUCH AS THINGS LIKE  
 PROTECTION OF THE ENVIRONMENT  
 423 01:19:28:25 01:19:31:22 BECAUSE THIS IS  
 A PARK AND WILDERNESS--  
 424 01:19:31:24 01:19:33:09 HAVE TO BE FOREMOST.  
 425 01:19:33:11 01:19:37:08 IT TAKES  
 VERY CAREFUL PLANNING  
 426 01:19:37:10 01:19:42:29 AND, UH, A STOUT HEART  
 427 01:19:43:01 01:19:45:13 DURING LONG, WINDY,  
 AND RAINY SPELLS.  
 428 01:19:45:15 01:19:49:23 IT ALSO, UH, GIVES YOU  
 429 01:19:49:25 01:19:54:08 A HUMBLE FEELING ABOUT  
 THE PEOPLE WHO CAME BEFORE  
 430 01:19:54:10 01:19:58:13 WHO HAD NO AIRCRAFT SUPPORT  
 AND NOT EVEN RADIOS,  
 431 01:19:58:15 01:20:01:12 WHERE JUST GETTING  
 TO THE COAST HERE  
 432 01:20:01:14 01:20:04:09 WAS A MAJOR AND  
 VERY LONG CHALLENGE,  
 433 01:20:04:11 01:20:08:08 LET ALONE WORKING HERE.  
 434 01:20:08:10 01:20:12:20 THE PROBLEMS ARE SERIOUS  
 435 01:20:12:22 01:20:18:03 AND WITH LACK OF ATTENTION  
 EVEN LIFE-THREATENING.  
 436 01:20:20:11 01:20:24:01 *GEOLOGIC INSIGHTS  
 FROM THE STUDY OF KATMAI*  
 437 01:20:24:03 01:20:25:12 *MAKE THE EFFORT  
 WORTHWHILE.*  
 438 01:20:25:14 01:20:28:08 *THE 1912 ERUPTION  
 WAS UNIQUE.*  
 439 01:20:28:10 01:20:30:22 *IT WAS A SINGLE,  
 WELL-DOCUMENTED*  
 440 01:20:30:24 01:20:32:12 *VOLCANIC EVENT*  
 441 01:20:32:14 01:20:35:18 *THAT TOOK PLACE IN A RATHER  
 SIMPLE GEOLOGIC SETTING.*  
 442 01:20:35:20 01:20:38:09 *AND THE SOURCE VENT  
 IS WELL-PRESERVED*  
 443 01:20:38:11 01:20:40:09 *BECAUSE  
 THE LARGE-SCALE COLLAPSE*  
 444 01:20:40:11 01:20:42:23 *THAT NORMALLY ACCOMPANIES  
 ERUPTIONS OF THIS SIZE*  
 445 01:20:42:25 01:20:46:17 *OCCURRED ELSEWHERE,  
 AT KATMAI'S SUMMIT.*  
 446 01:20:46:19 01:20:50:22 *THE RESEARCH CURRENTLY  
 UNDERWAY HAS SEVERAL GOALS.*  
 447 01:20:50:24 01:20:53:09 *GEOLOGISTS HOPE TO CHART*

448 01:20:53:11 01:20:55:24 *THE UNDERGROUND STRUCTURE  
OF THE VENT*

449 01:20:55:26 01:20:58:23 *AND UNCOVER CLUES  
TO THE EXPLOSIVE PROCESS.*

450 01:20:58:25 01:21:01:06 *THEY WOULD FURTHER LIKE  
TO UNDERSTAND*

451 01:21:01:08 01:21:04:12 *HOW HEAT ESCAPES  
FROM THE ERUPTION DEPOSIT.*

452 01:21:05:22 01:21:07:21 *IN ORDER TO DO THIS,*

453 01:21:07:23 01:21:10:20 *INDIRECT TECHNIQUES ARE  
NEEDED TO SURVEY THE AREA*

454 01:21:10:22 01:21:13:20 *BECAUSE IMPORTANT EVIDENCE  
IS BURIED TOO DEEP*

455 01:21:13:22 01:21:15:22 *TO EXAMINE DIRECTLY.*

456 01:21:15:24 01:21:18:21 *THE CLEVER WAYS  
THESE SURVEYS ARE DESIGNED*

457 01:21:18:23 01:21:20:09 *ILLUSTRATE HOW SCIENTISTS*

458 01:21:20:11 01:21:23:20 *HAVE RISEN TO THE CHALLENGE  
OF STUDYING VOLCANOES.*

459 01:21:27:26 01:21:29:12 *FOR EXAMPLE,*

460 01:21:29:14 01:21:32:07 *GEOPHYSICISTS MEASURE  
THE RESISTANCE OF THE ROCKS*

461 01:21:32:09 01:21:35:06 *TO ELECTRICAL CURRENTS  
SHOT INTO THE GROUND.*

462 01:21:35:08 01:21:38:05 *THE MORE EASILY  
ELECTRICITY FLOWS,*

463 01:21:38:07 01:21:41:06 *THE MORE LIKELY THE GROUND  
IS TO CONTAIN WATER*

464 01:21:41:08 01:21:43:02 *BECAUSE WATER  
IS AN EXCELLENT*

465 01:21:43:04 01:21:44:01 *ELECTRICAL CONDUCTOR.*

466 01:21:44:03 01:21:46:22 *THIS SITE HAS  
A LOT OF CLAY.*

467 01:21:46:24 01:21:48:21 *MEASURING  
ELECTRICAL CONDUCTIVITY*

468 01:21:48:23 01:21:52:06 *NOT ONLY PROVIDES A CLUE  
TO THE WATER CONTENT*

469 01:21:52:08 01:21:53:21 *OF SUBTERRANEAN DEPOSITS,*

470 01:21:53:23 01:21:55:21 *IT ALSO HELPS  
THE SCIENTISTS*

471 01:21:55:23 01:21:58:05 *STUDY HOW  
THE DEPOSITS HAVE COOLED*

472 01:21:58:07 01:22:00:19 *BECAUSE WATER IS  
AN IMPORTANT AGENT*

473 01:22:00:21 01:22:03:04 *FOR TRANSPORTING HEAT  
OUT OF VOLCANIC ROCKS.*

474 01:22:03:06 01:22:05:21 *OK, I'LL SEE  
HOW THIS LOOKS.*

475 01:22:05:23 01:22:08:05 *I'M GOING  
TO BREAK OUT OF THAT.*

476 01:22:08:07 01:22:09:28 *THAT LOOKS GOOD, DON.*

477 01:22:10:00 01:22:11:14 *GREAT.*

478 01:22:11:16 01:22:14:26 *SINCE SOME ROCKS ARE  
MORE MAGNETIC THAN OTHERS,*

479 01:22:14:28 01:22:16:10 *GEOPHYSICISTS  
ALSO MAP VARIATIONS*

480 01:22:16:12 01:22:18:06 *IN MAGNETISM TO HELP STUDY*  
 481 01:22:18:08 01:22:23:05 *THE SUBTERRANEAN STRUCTURE*  
     *OF THE VENT AREA.*  
 482 01:22:23:07 01:22:25:20 EVERY ROCK HAS  
     SOME MAGNETIC SIGNATURE  
 483 01:22:25:22 01:22:28:18 OR SOME MAGNETIC FIELD  
     ASSOCIATED WITH IT,  
 484 01:22:28:20 01:22:30:16 THAT WAS BLOCKED INTO IT  
 485 01:22:30:18 01:22:33:11 WHEN IT COOLED BELOW  
     A CERTAIN TEMPERATURE.  
 486 01:22:33:13 01:22:34:17 AND...  
 487 01:22:34:19 01:22:37:02 THE PROTON  
     PROCESSION MAGNETOMETER  
 488 01:22:37:04 01:22:40:18 MEASURES THE INTENSITY  
     OF THE FIELD AT THAT POINT.  
 489 01:22:40:20 01:22:43:17 THEN WITH ANOTHER  
     INSTRUMENT IN ONE PLACE  
 490 01:22:43:19 01:22:46:18 RECORDING VARIATIONS IN  
     THE EARTH'S MAGNETIC FIELD--  
 491 01:22:46:20 01:22:50:18 THE DAILY VARIATIONS--  
     WE SUBTRACT THE TWO.  
 492 01:22:50:20 01:22:52:20 WE'RE LEFT  
     WITH A COMPONENT  
 493 01:22:52:22 01:22:56:24 WHICH WE HOPE IS JUST  
     THE ROCKS THEMSELVES.  
 494 01:22:56:26 01:22:59:08 *MAGNETIC SURVEYING*  
     *REVEALS THAT THE AREA*  
 495 01:22:59:10 01:23:02:02 *NEAR NOVARUPTA*  
     *IS MORE MAGNETIC*  
 496 01:23:02:04 01:23:04:20 *THAN SURROUNDING TERRAIN.*  
 497 01:23:04:22 01:23:07:06 *THE RESEARCH TEAM*  
     *BELIEVES THIS RESULTS*  
 498 01:23:07:08 01:23:10:06 *FROM A CONCENTRATION*  
     *OF IRON-RICH MINERALS*  
 499 01:23:10:08 01:23:13:03 *WITHIN AND BENEATH*  
     *THE DOME.*  
 500 01:23:13:05 01:23:16:02 *THE VENT*  
     *ENCLOSING NOVARUPTA*  
 501 01:23:16:04 01:23:19:02 *IS LARGELY FILLED WITH*  
     *LOW-DENSITY ASH AND PUMICE,*  
 502 01:23:19:04 01:23:21:16 *WHICH EXERTS A WEAKER*  
     *PULL OF GRAVITY*  
 503 01:23:21:18 01:23:23:02 *THAN THE SURROUNDING ROCK.*  
 504 01:23:23:04 01:23:24:29 *SO, YET ANOTHER*  
     *GEOPHYSICAL PROPERTY--*  
 505 01:23:25:01 01:23:27:29 *VARIATIONS IN GRAVITY--*  
     *MAY BE USED TO TRACE*  
 506 01:23:28:01 01:23:30:19 *THE UNDERLYING PATTERN*  
     *OF THE ROCKS.*  
 507 01:23:36:19 01:23:38:17 WELL, IN A SIMPLIFIED MANNER,  
 508 01:23:38:19 01:23:43:02 THERE'S A MASS ON THE END  
     OF A SPRING INSIDE HERE.  
 509 01:23:43:04 01:23:45:03 AND, UH, THE MASS--  
 510 01:23:45:05 01:23:49:18 WELL, THE SPRING IS EXTENDED  
     BY THE WEIGHT OF THE MASS  
 511 01:23:49:20 01:23:53:02 AND THAT MASS WILL



512 01:23:53:04 ACTUALLY BE PULLED DOWN  
 01:23:56:17 BY THE MASS UNDERNEATH,  
 IN THE EARTH  
 513 01:23:56:19 01:23:59:28 AND SO, THE GREATER  
 THE MASS IN THE EARTH,  
 514 01:24:00:02 01:24:03:24 THE MORE THE SPRING  
 WILL BE EXTENDED.  
 515 01:24:03:26 01:24:06:20 BASICALLY WE MEASURE  
 THE EXTENSION OF THE SPRING  
 516 01:24:06:22 01:24:08:16 IN A VERY PRECISE MANNER.  
 517 01:24:08:18 01:24:10:01 GEOLOGISTS AT KATMAI  
 518 01:24:10:03 01:24:12:00 WOULD ALSO LIKE  
 TO LEARN MORE  
 519 01:24:12:02 01:24:15:14 ABOUT THE RELATIONSHIP OF ORE  
 DEPOSITS TO VOLCANIC ACTIVITY,  
 520 01:24:15:16 01:24:17:15 FOR IN THE FUMAROLIC GASES  
 521 01:24:17:17 01:24:20:16 OF THE VALLEY  
 OF 10,000 SMOKES  
 522 01:24:20:18 01:24:23:22 METALLIC ORE MINERALS  
 HAVE FORMED.  
 523 01:24:23:24 01:24:25:19 SINCE THE ERUPTION IN 1912,  
 524 01:24:25:21 01:24:29:07 STREAMS HAVE CUT DEEP CHANNELS  
 INTO THE ASH DEPOSITS,  
 525 01:24:29:09 01:24:33:07 EXPOSING MANY OF THE FUMAROLES  
 IN CROSS-SECTION.  
 526 01:24:33:09 01:24:35:12 THIS ALLOWS GEOLOGISTS  
 527 01:24:35:14 01:24:38:16 TO EXAMINE THE STRUCTURE  
 AND MINERAL DEPOSITS  
 528 01:24:38:18 01:24:40:01 BENEATH THE FUMAROLES  
 529 01:24:40:03 01:24:42:01 ORDINARILY  
 HIDDEN FROM VIEW.  
 530 01:24:42:03 01:24:44:00 ESPECIALLY INTRIGUING  
 ARE MINERAL DEPOSITS  
 531 01:24:44:02 01:24:46:22 SUBLIMATED FROM THE HOT  
 VOLCANIC VAPORS.  
 532 01:24:49:14 01:24:52:12 ALTHOUGH MUCH DATA  
 HAVE ALREADY BEEN COLLECTED,  
 533 01:24:52:14 01:24:55:26 THE KATMAI PROJECT IS STILL  
 IN ITS PRELIMINARY STAGES.  
 534 01:24:55:28 01:24:58:13 RESEARCH MAY CONTINUE HERE  
 FOR YEARS,  
 535 01:24:58:15 01:25:00:09 BRINGING WITH IT, NO DOUBT,  
 536 01:25:00:11 01:25:01:29 SURPRISING NEW DISCOVERIES  
 537 01:25:02:01 01:25:04:28 THAT WILL HAVE IMPLICATIONS  
 FAR BEYOND THIS REGION.  
 538 01:25:05:00 01:25:09:28 SOME OF THIS WORK WILL  
 HAVE APPLICATION ELSEWHERE.  
 539 01:25:10:00 01:25:12:13 IN TERMS OF UNDERSTANDING  
 EXPLOSIVE VOLCANISM,  
 540 01:25:12:15 01:25:13:27 UNDERSTANDING THE PROCESSES  
 541 01:25:13:29 01:25:16:29 CERTAINLY SHOULD  
 ALLOW US IN THE FUTURE  
 542 01:25:17:01 01:25:19:28 TO BE BETTER AT PREDICTING  
 ERUPTIVE EVENTS  
 543 01:25:20:00 01:25:22:28 AND UNDERSTANDING  
 WHAT THE CONSEQUENCES

OF ERUPTIVE EVENTS  
 544 01:25:23:00 01:25:24:13 ARE LIKELY TO BE.  
 545 01:25:24:15 01:25:26:28 AND FOR PEOPLE LIVING  
 AROUND VOLCANOES,  
 546 01:25:27:00 01:25:29:29 AS MANY PEOPLE  
 IN WESTERN U.S. DO,  
 547 01:25:30:01 01:25:32:29 AND MANY OTHER AREAS  
 IN THE WORLD,  
 548 01:25:33:01 01:25:34:27 THAT'S A SERIOUS PROBLEM.  
 549 01:25:34:29 01:25:39:28 UNDERSTANDING HOW  
 METALS GET TRANSPORTED  
 IN THE IGNEOUS SYSTEMS  
 550 01:25:40:00 01:25:47:04 MAY HELP US TO BETTER  
 EXPLOIT ORE DEPOSITS.  
 551 01:25:47:06 01:25:52:13 AND UNDERSTANDING HOW  
 HEAT ESCAPES FROM MAGMA  
 552 01:25:52:15 01:25:55:12 AND HOW HYDROTHERMAL  
 SYSTEMS DEVELOP  
 553 01:25:55:14 01:25:57:13 MAY HELP IN THE FUTURE  
 554 01:25:57:15 01:26:01:11 IN EXPLORATION AND  
 USE OF GEOTHERMAL ENERGY,  
 555 01:26:01:13 01:26:04:11 WHICH IN SOME PARTS  
 OF THE WORLD  
 556 01:26:04:13 01:26:07:20 IS AN IMPORTANT  
 AND USEFUL ENERGY SOURCE.  
 557 01:26:09:05 01:26:12:11 MANY PEOPLE THINK OF VOLCANOES  
 ONLY AS A GEOLOGIC HAZARD  
 558 01:26:12:13 01:26:14:11 THAT DESTROY LIVES  
 AND BUILDINGS,  
 559 01:26:14:13 01:26:17:10 BUT THERE ARE BENEFICIAL  
 ASPECTS TO VOLCANOES AS WELL.  
 560 01:26:17:12 01:26:19:07 VOLCANIC ROCKS DECOMPOSE  
 VERY RAPIDLY  
 561 01:26:19:09 01:26:21:16 AND FORM SOILS  
 THAT ARE RICH  
 562 01:26:21:18 01:26:23:27 IN THE NUTRIENTS  
 USED BY PLANTS.  
 563 01:26:23:29 01:26:26:21 IN FACT, SOILS DERIVED  
 FROM VOLCANIC ROCKS  
 564 01:26:26:23 01:26:29:17 ARE AMONG THE MOST  
 FERTILE IN THE WORLD.  
 565 01:26:29:19 01:26:31:26 IRONICALLY, IT'S THIS  
 CONNECTION WITH AGRICULTURE  
 566 01:26:31:28 01:26:34:22 THAT INDUCES ABOUT 10%  
 OF THE WORLD'S POPULATION  
 567 01:26:34:24 01:26:37:12 TO LIVE IN THE SHADOW  
 OF ACTIVE VOLCANOES.  
 568 01:26:37:14 01:26:38:27 HOT SPRINGS, LIKE THIS ONE,  
 569 01:26:38:29 01:26:40:27 ARE VERY COMMON  
 IN VOLCANIC AREAS  
 570 01:26:40:29 01:26:43:05 IN MANY PARTS OF THE WORLD,  
 571 01:26:43:07 01:26:45:02 THIS VOLCANIC HEAT  
 IS COLLECTED  
 572 01:26:45:04 01:26:46:26 AND USED TO GENERATE  
 ELECTRICITY  
 573 01:26:46:28 01:26:48:11 OR DIRECTLY HEAT BUILDINGS.

574 01:26:48:13 01:26:53:05 THE CAPITAL OF ICELAND,  
 A CITY OF OVER 100,000 PEOPLE,  
 575 01:26:53:07 01:26:55:27 IS HEATED ALMOST EXCLUSIVELY  
 USING GEOTHERMAL ENERGY.  
 576 01:26:55:29 01:26:57:05 THE BENEFITS OF VOLCANOES  
 577 01:26:57:07 01:26:59:12 EXTEND BEYOND  
 OUR HOMES AND AGRICULTURE,  
 578 01:26:59:14 01:27:00:27 EVEN BEYOND HUMAN HISTORY.  
 579 01:27:00:29 01:27:03:18 OCEANIC VOLCANISM RECREATES  
 THE EARTH'S OCEAN BASINS  
 580 01:27:03:20 01:27:06:00 ABOUT ONCE  
 EVERY 120 MILLION YEARS.  
 581 01:27:06:02 01:27:08:09 AND VOLCANISM EARLY  
 IN EARTH'S HISTORY  
 582 01:27:08:11 01:27:11:09 IS THOUGHT TO HAVE PRODUCED  
 MOST OF THE WATER  
 583 01:27:11:11 01:27:13:10 IN OUR OCEANS  
 AND ATMOSPHERE.  
 584 01:27:13:12 01:27:16:13 SO VOLCANOES ATTRACT  
 THE ATTENTION OF GEOLOGISTS  
 585 01:27:16:15 01:27:18:02 FOR MANY REASONS--  
 586 01:27:18:04 01:27:19:24 FOR THEIR POWER TO DESTROY  
 587 01:27:19:26 01:27:22:00 AND THEIR ECONOMIC BENEFITS,  
 588 01:27:22:02 01:27:24:08 AND ULTIMATELY FOR  
 THEIR CRITICAL ROLE  
 589 01:27:24:10 01:27:26:10 IN THE EVOLUTION  
 OF OUR PLANET.  
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