1 00:00:39:27 00:00:43:09 Annenberg Media
2 00:00:43:11 00:01:33:12 §
3 00:01:33:14 00:01:36:03 [SPEAKING SPANISH]
4 00:02:02:28 00:02:05:10 *HISTORIAN WILL DURANT ONCE OBSERVED*
5 00:02:05:12 00:02:08:24 *THAT CIVILIZATION EXISTS BY GEOLOGICAL CONSENT,*
6 00:02:08:26 00:02:10:24 *SUBJECT TO CHANGE WITHOUT NOTICE.*
7 00:02:10:26 00:02:13:09 *DURANT MAY NOT HAVE HAD EARTHQUAKES*
8 00:02:13:11 00:02:14:25 *SPECIFICALLY IN MIND*
9 00:02:14:27 00:02:16:24 *WHEN HE MADE THAT STATEMENT,*
10 00:02:16:26 00:02:18:23 *BUT IT'S DIFFICULT TO IMAGINE*
11 00:02:18:25 00:02:20:24 *A MORE CATACLYSMIC EVENT*
12 00:02:20:26 00:02:22:10 *THAN A MAJOR EARTHQUAKE.*
13 00:02:24:27 00:02:27:09 *ANCIENT MYTHOLOGY HELD THAT TREMORS OCCURRED*
14 00:02:27:11 00:02:28:24 *DUE TO THE MOVEMENTS*
15 00:02:28:26 00:02:31:17 *OF GIANT ANIMALS BENEATH THE EARTH.*
16 00:02:33:03 00:02:36:16 *WHILE SCIENCE HAS SINCE PROVED SUCH NOTIONS INCORRECT,*
17 00:02:36:18 00:02:38:00 *THESE MYTHS DID CONTAIN*
18 00:02:38:02 00:02:40:17 *AT LEAST ONE ELEMENT OF TRUTH--*
19 00:02:40:19 00:02:43:17 *THE CAUSE FOR THE ABRUPTLY SHIFTING LAND*
20 00:02:43:19 00:02:46:00 *DOES RESIDE DEEP BELOW OUR FEET.*
21 00:02:48:10 00:02:50:08 *BUT INSTEAD OF THE LAND*
22 00:02:50:10 00:02:52:08 *SITTING ON A MYTHOLOGICAL BEAST,*
23 00:02:52:10 00:02:55:25 *WE RIDE ATOP A GIGANTIC HEAT-TRANSPORTING MACHINE*
24 00:02:55:27 00:02:59:15 *THAT KEEPS DEEP ROCK FLOWING AND CHURNING.*
25 00:03:00:27 00:03:03:16 *RADIOACTIVE DECAY GENERATES THE HEAT ENERGY*
26 00:03:03:18 00:03:05:01 *WHICH ULTIMATELY POWERS MOVEMENTS*
27 00:03:05:03 00:03:08:05 *OF EARTH'S ROCKY TECTONIC PLATES.*
28 00:03:10:10 00:03:12:22 *THE FRICTION BETWEEN THE ROUGH EDGES*
29 00:03:12:24 00:03:14:24 *OF THESE SLOWLY MOVING SEGMENTS*
30 00:03:14:26 00:03:16:09 *OF THE EARTH'S LITHOSPHERE*
31 00:03:16:11 00:03:19:23 *RESULTS IN A SERIES OF JERKY STARTS AND STOPS*
32 00:03:19:25 00:03:23:07 *WHICH IS THE DIRECT CAUSE OF MOST MAJOR EARTHQUAKES.*
33 00:03:24:25 00:03:27:22 *THE SAME HEAT ENGINE*

THAT PRODUCES EARTHQUAKES

34 00:03:27:24 00:03:29:09 *IS THE DRIVING FORCE*

35 00:03:29:11 00:03:32:10 *RAISING THE WORLD'S GREAT MOUNTAIN RANGES.*

36 00:03:32:12 00:03:35:09 *IF THIS UPLIFT DID NOT TAKE PLACE,*

37 00:03:35:11 00:03:37:08 *THE RELENTLESS FORCE OF EROSION*

38 00:03:37:10 00:03:39:08 *WOULD REDUCE THE EARTH'S LANDSCAPE*

39 00:03:39:10 00:03:41:07 *TO A SINGLE FLAT PLAIN.*

40 00:03:42:27 00:03:45:10 *WITHOUT THE PRESENT RANGE OF ELEVATIONS,*

41 00:03:45:12 00:03:49:07 *RIVERS WOULD LOSE THEIR PRINCIPAL SOURCES OF WATER,*

42 00:03:49:09 00:03:55:00 *THE LAND WOULD ULTIMATELY ERODE DOWN TO TIDE LEVEL,*

43 00:03:55:02 00:03:57:00 *AND MOST OF THE DIVERSITY*

44 00:03:57:02 00:03:59:24 *IN THE WORLD'S FLORA AND FAUNA WOULD DISAPPEAR.*

45 00:03:59:26 00:04:01:03 *AND YET,*

46 00:04:01:05 00:04:02:26 *WHILE THERE ARE INDIRECT BENEFITS*

47 00:04:02:28 00:04:06:08 *TO LIVING IN A WORLD WITH EARTHQUAKES,*

48 00:04:06:10 00:04:08:07 *IT'S THE CAPACITY OF TREMORS*

49 00:04:08:09 00:04:10:07 *TO VIOLENTLY DISRUPT HUMAN ACTIVITY*

50 00:04:10:09 00:04:11:21 *THAT COMMANDS OUR ATTENTION.*

51 00:04:16:05 00:04:18:01 @

52 00:04:16:05 00:04:18:01 EARTHQUAKES OFTEN OCCUR HERE--

53 00:04:18:03 00:04:21:01 ON THE SAN ANDREAS FAULT IN CALIFORNIA.

54 00:04:21:03 00:04:23:16 THIS FAULT IS ACTUALLY THE BOUNDARY

55 00:04:23:18 00:04:25:01 BETWEEN TWO TECTONIC PLATES--

56 00:04:25:03 00:04:27:15 THE NORTH AMERICAN AND PACIFIC PLATES.

57 00:04:27:17 00:04:28:20 IN 1857,

58 00:04:28:22 00:04:31:02 THIS SEGMENT OF THE SAN ANDREAS

59 00:04:31:04 00:04:32:17 CAUSED A MASSIVE EARTHQUAKE.

60 00:04:32:19 00:04:35:16 THE GROUND ON EITHER SIDE OF THE FAULT

61 00:04:35:18 00:04:36:29 SHIFTED SUDDENLY AND VIOLENTLY,

62 00:04:37:01 00:04:39:00 MOVING AS MUCH AS 4 METERS.

63 00:04:39:02 00:04:41:19 INSTRUMENTS TO MEASURE

THE STRENGTH OF THE QUAKE

64 00:04:41:21 00:04:43:05 DIDN'T EXIST
AT THE TIME,

65 00:04:43:07 00:04:44:14 BUT ESTIMATES

66 00:04:44:16 00:04:46:19 BASED ON EYEWITNESS
ACCOUNTS OF THE DAMAGE

67 00:04:46:21 00:04:48:25 RANGE AS HIGH AS
8.2 ON THE RICHTER SCALE.

68 00:04:48:27 00:04:50:25 SINCE THEN,
CALIFORNIA HAS EXPERIENCED

69 00:04:50:27 00:04:52:23 SEVERAL
DEVASTATING EARTHQUAKES.

70 00:04:52:25 00:04:54:23 IN FACT,
THOUSANDS OF EARTHQUAKES

71 00:04:54:25 00:04:56:22 ON HUNDREDS
OF DIFFERENT FAULTS

72 00:04:56:24 00:04:58:09 SHAKE CALIFORNIA
EACH YEAR.

73 00:04:58:11 00:05:01:10 BUT EARTHQUAKES ARE NOT
JUST A CALIFORNIA STORY.

74 00:05:01:12 00:05:03:10 THEY OCCUR
THROUGHOUT THE WORLD.

75 00:05:03:12 00:05:05:24 IN REGIONS THAT
ARE DENSELY POPULATED

76 00:05:05:26 00:05:07:24 AND WHERE CONSTRUCTION
PRACTICES ARE PRIMITIVE,

77 00:05:07:26 00:05:09:24 THE DESTRUCTION
AND LOSS OF LIFE

78 00:05:09:26 00:05:11:09 FROM A POWERFUL
EARTHQUAKE

79 00:05:11:11 00:05:12:24 CAN BE ALMOST
INCOMPREHENSIBLE.

80 00:05:12:26 00:05:15:23 IN 1990, 50,000 PEOPLE
DIED IN IRAN.

81 00:05:15:25 00:05:17:08 THE YEAR BEFORE,

82 00:05:17:10 00:05:19:25 25,000 PEOPLE WERE
KILLED IN ARMENIA.

83 00:05:19:27 00:05:21:10 AND IN CHINA,

84 00:05:21:12 00:05:23:09 HUNDREDS OF THOUSANDS
OF PEOPLE

85 00:05:23:11 00:05:26:10 WERE KILLED IN
A SINGLE EARTHQUAKE IN 1976.

86 00:05:26:12 00:05:28:05 EARTHQUAKES
ARE SHOCK WAVES.

87 00:05:28:07 00:05:30:26 THEY'RE PRODUCED WHEN
ROCKS BREAK AND VIBRATE

88 00:05:30:28 00:05:33:26 WHEN TWO BLOCKS
OF THE EARTH'S CRUST

89 00:05:33:28 00:05:35:11 SLIDE PAST ONE ANOTHER.

90 00:05:35:13 00:05:37:09 THIS USUALLY OCCURS
ALONG A FAULT,

91 00:05:37:11 00:05:39:09 WHICH IS A ZONE
OF WEAKNESS

92 00:05:39:11 00:05:40:23 IN THE EARTH'S CRUST.

93 00:05:40:25 00:05:42:23 MOVEMENT
OF THE EARTH'S CRUST

94 00:05:42:25 00:05:44:07 CAUSES STRESS
TO ACCUMULATE
95 00:05:44:09 00:05:46:23 IN THE ROCKS
OF THE FAULT ZONE.
96 00:05:46:25 00:05:49:23 I CAN FEEL THE STRESS
ACCUMULATING IN MY HANDS
97 00:05:49:25 00:05:52:23 AS I TRY TO SLIDE THEM
PAST ONE ANOTHER.
98 00:05:52:25 00:05:54:09 THE ROCKS WILL BREAK
99 00:05:54:11 00:05:55:23 WHEN THE ACCUMULATED STRESS
100 00:05:55:25 00:05:58:22 EXCEEDS THE STRENGTH
OF THE ROCKS IN THE FAULT.
101 00:05:58:24 00:06:00:22 THE MOVEMENT
OF THE TECTONIC PLATES
102 00:06:00:24 00:06:03:17 IS THE PRINCIPAL SOURCE OF
STRESS IN THE EARTH'S CRUST.
103 00:06:03:19 00:06:05:16 THE STRESS THAT ACCUMULATES
OVER HUNDREDS
104 00:06:05:18 00:06:07:03 OR EVEN THOUSANDS OF YEARS
105 00:06:07:05 00:06:09:24 IS RELEASED IN AN INSTANT
AS AN EARTHQUAKE.
106 00:06:09:26 00:06:11:08 GEOLOGISTS STUDY
THE MECHANICS
107 00:06:11:10 00:06:12:23 OF EARTHQUAKE BEHAVIOR
108 00:06:12:25 00:06:14:08 TO DEVELOP
AN UNDERSTANDING
109 00:06:14:10 00:06:15:23 OF WHERE AND WHEN
110 00:06:15:25 00:06:18:08 EARTHQUAKES ARE
MOST LIKELY TO HAPPEN.
111 00:06:18:10 00:06:22:03 *MOST OF THE ENERGY IN*
AN EARTHQUAKE IS EXPENDED
112 00:06:22:05 00:06:26:02 *WHEN BLOCKS OF ROCK*
MOVE INTO NEW POSITIONS.
113 00:06:26:04 00:06:28:17 *THE ENERGY*
FRACTURES THE ROCK,
114 00:06:28:19 00:06:31:17 *FORMING A PLANE OF SLIP,*
CALLED A FAULT,
115 00:06:31:19 00:06:33:02 *ALONG WHICH*
FUTURE EARTHQUAKES
116 00:06:33:04 00:06:35:08 *CAN ALSO OCCUR.*
117 00:06:35:10 00:06:37:29 *SOME ENERGY GENERATES*
FRICTIONAL HEAT,
118 00:06:38:01 00:06:41:03 *AND A SMALL PART*
OF THE ENERGY RELEASED
119 00:06:41:05 00:06:42:25 *CREATES SEISMIC WAVES.*
120 00:06:42:27 00:06:45:23 UH, 19 INCHES AGAIN.
121 00:06:45:25 00:06:47:22 *THESE WAVES*
CAN BE CATEGORIZED
122 00:06:47:24 00:06:50:08 *ACCORDING TO*
THE FORM THEY TAKE
123 00:06:50:10 00:06:53:08 *AND THE SPEED*
AT WHICH THEY TRAVEL.
124 00:06:53:10 00:06:56:09 OF THOSE THAT TRAVEL
IN SUCH A WAY
125 00:06:56:11 00:06:59:09 THAT THE MATTER THROUGH WHICH
THE WAVES ARE TRAVELING

126 00:06:59:11 00:07:01:08 ARE ALTERNATELY
COMPRESSED AND DILATATED,
127 00:07:01:10 00:07:03:08 THESE ARE
CALLED P WAVES
128 00:07:03:10 00:07:05:07 BECAUSE THESE
ARE THE FIRST ONES,
129 00:07:05:09 00:07:06:23 THE PRIMARY WAVES,
130 00:07:06:25 00:07:08:18 TO ARRIVE
AT A SEISMOGRAPH.
131 00:07:08:20 00:07:11:18 S WAVES, WHICH ARE SOMETIMES
CALLED SECONDARY WAVES
132 00:07:11:20 00:07:13:03 OR SHEAR WAVES,
133 00:07:13:05 00:07:16:15 ARE WAVES WHICH TRAVEL
BY A WAVELIKE MOTION
134 00:07:16:17 00:07:19:00 WHERE THE MATTER
IS VIBRATING UP AND DOWN
135 00:07:19:02 00:07:20:29 AT RIGHT ANGLES
TO THE DIRECTION
136 00:07:21:01 00:07:24:01 THAT THE WAVE ENERGY
IS BEING PROPAGATED.
137 00:07:24:03 00:07:27:00 THIS CAUSES A SHEAR STRESS
TO DEVELOP
138 00:07:27:02 00:07:29:01 IN THE ROCKS
THROUGH WHICH IT TRAVELS,
139 00:07:29:03 00:07:31:16 WHY THEY'RE CALLED
SHEAR WAVES OR S WAVES.
140 00:07:31:18 00:07:34:15 THE S WAVES TRAVEL SOMEWHAT
SLOWER THAN THE P WAVES--
141 00:07:34:17 00:07:37:15 THE DIFFERENCE IN SPEED
ABOUT 2 KILOMETERS A SECOND.
142 00:07:39:15 00:07:40:28 *THIS DIFFERENCE*
IN VELOCITY
143 00:07:41:00 00:07:44:22 *BETWEEN P AND S WAVES*
IS HIGHLY SIGNIFICANT.
144 00:07:44:24 00:07:47:02 *IT ENABLES SEISMOLOGISTS*
145 00:07:47:04 00:07:49:02 *TO CALCULATE*
THE PRECISE LOCATION
146 00:07:49:04 00:07:51:14 *WHERE AN EARTHQUAKE*
HAS OCCURRED.
147 00:07:51:16 00:07:55:13 IF ONE LIES CLOSE TO
THE EPICENTER OF AN EARTHQUAKE,
148 00:07:55:15 00:07:57:28 THE P AND THE S WAVES
149 00:07:58:00 00:08:00:12 WILL NOT HAVE HAD
ENOUGH TIME
150 00:08:00:14 00:08:02:12 TO BECOME SEPARATE
FROM ONE ANOTHER
151 00:08:02:14 00:08:04:13 AS THEY TRAVEL
THROUGH THE EARTH.
152 00:08:04:15 00:08:06:12 THEY ARRIVE
ALL AT ONCE,
153 00:08:06:14 00:08:08:29 AND THE EARTHQUAKE IS FELT
AS A SHARP JOLT.
154 00:08:09:01 00:08:12:13 IF ONE LIES AT A GREAT DISTANCE
FROM THE EPICENTER,
155 00:08:12:15 00:08:16:13 THE P WAVES WILL HAVE
FAR OUTRACED THE S WAVES

156 00:08:16:15 00:08:19:13 AND ARRIVE MUCH EARLIER
THAN THE S WAVES DO.
157 00:08:19:15 00:08:20:29 THE TIME INTERVAL
158 00:08:21:01 00:08:23:29 BETWEEN THE ARRIVAL
OF THE P AND S WAVES
159 00:08:24:01 00:08:27:13 THUS IS A FUNCTION OF
THE DISTANCE TO THE SOURCE--
160 00:08:27:15 00:08:28:20 THE EPICENTER.
161 00:08:28:22 00:08:31:02 HAVING A SINGLE
SEISMOGRAPH RECORD
162 00:08:31:04 00:08:32:28 SHOWING THE TIME INTERVAL
163 00:08:33:00 00:08:35:16 BETWEEN THE ARRIVAL
OF S AND P WAVES
164 00:08:35:18 00:08:37:24 IS NOT ADEQUATE
FOR LOCATING THE EPICENTER.
165 00:08:37:26 00:08:39:20 IT SIMPLY TELLS ONE
166 00:08:39:22 00:08:42:19 HOW FAR AWAY
THE EARTHQUAKE OCCURRED.
167 00:08:42:21 00:08:47:13 THE DIRECTION IS STILL MISSING
FROM THIS INFORMATION.
168 00:08:47:15 00:08:49:28 IN ORDER TO DETERMINE
THAT DIRECTION,
169 00:08:50:00 00:08:53:16 ONE EXAMINES
SEISMOGRAPH RECORDS
170 00:08:53:18 00:08:57:24 FROM OTHER STATIONS
IN THE REGIONS AS WELL.
171 00:08:57:26 00:09:00:11 ONE CAN PULL OUT A MAP
172 00:09:00:13 00:09:03:04 AND EASILY LOCATE
THE EPICENTER
173 00:09:03:06 00:09:06:10 BY DRAWING CIRCLES
174 00:09:06:12 00:09:09:11 AROUND EACH RESPECTIVE
SEISMIC STATION,
175 00:09:09:13 00:09:10:26 REPRESENTING THE DISTANCE
176 00:09:10:28 00:09:13:25 INFERRED TO THE SOURCE
OF THE EARTHQUAKE
177 00:09:13:27 00:09:17:27 BASED ON THE TIME INTERVAL
BETWEEN S AND P WAVES,
178 00:09:17:29 00:09:19:11 AND WHERE THESE
CIRCLES INTERSECT,
179 00:09:19:13 00:09:20:26 BINGO, THAT'S YOUR SOURCE.
180 00:09:20:28 00:09:22:26 THAT'S WHERE
THE EARTHQUAKE ENERGY
181 00:09:22:28 00:09:24:10 FIRST REACHED
THE EARTH'S SURFACE.
182 00:09:26:18 00:09:29:02 IN THE SECOND CENTURY,
CHINESE BUILT A DEVICE
183 00:09:29:04 00:09:31:18 THAT COULD DETECT
THE INITIAL GROUND MOTION
184 00:09:31:20 00:09:33:01 DURING AN EARTHQUAKE.
185 00:09:33:03 00:09:35:03 IT CONSISTED
OF EIGHT METAL BALLS
186 00:09:35:05 00:09:36:09 ARRANGED AROUND
THE CIRCUMFERENCE
187 00:09:36:11 00:09:37:12 OF A LARGE SPHERE.
188 00:09:37:14 00:09:39:09 IF THE EARTH
SHOOK HARD ENOUGH,

189 00:09:39:11 00:09:41:09 A SMALL PENDULUM
INSIDE THE SPHERE
190 00:09:41:11 00:09:42:24 SWUNG BACK AND FORTH,
191 00:09:42:26 00:09:45:09 KNOCKING ONE OF
THE BALLS OFF ITS STAND.
192 00:09:45:11 00:09:46:24 THIS INDICATED
THE DIRECTION
193 00:09:46:26 00:09:49:08 THAT THE EARTHQUAKE
VIBRATIONS CAME FROM.
194 00:09:49:10 00:09:50:23 AT THE TURN OF THE CENTURY,
195 00:09:50:25 00:09:52:10 AN ADVANCED DEVICE
WAS DESIGNED--
196 00:09:52:12 00:09:54:24 ONE TO MAKE A PERMANENT
RECORD OF GROUND MOTION
197 00:09:54:26 00:09:56:09 DURING AN EARTHQUAKE.
198 00:09:56:11 00:09:58:24 THIS INSTRUMENT, CALLED
A DUPLEX PENDULUM SEISMOGRAPH,
199 00:09:58:26 00:10:00:23 RECORDED THE SHAKING
OF THE GROUND
200 00:10:00:25 00:10:03:24 AS A CONTINUOUS SQUIGGLE
ON A PIECE OF PAPER.
201 00:10:03:26 00:10:05:25 THIS DEVICE RECORDED
THE GROUND MOTION
202 00:10:05:27 00:10:08:03 OF THE 1906
SAN FRANCISCO EARTHQUAKE.
203 00:10:08:05 00:10:09:18 THE INVENTION OF A DEVICE
204 00:10:09:20 00:10:12:03 THAT COULD ACCURATELY MEASURE
AN EARTHQUAKE'S STRENGTH
205 00:10:12:05 00:10:14:03 WAS A SIGNIFICANT
SCIENTIFIC ACHIEVEMENT.
206 00:10:14:05 00:10:15:18 THESE MODERN SEISMOGRAPHS
207 00:10:15:20 00:10:17:19 OPERATE ON THE SAME
GENERAL PRINCIPLES
208 00:10:17:21 00:10:19:17 AS THE EARLY
PENDULUM INSTRUMENTS,
209 00:10:19:19 00:10:22:03 BUT THEY ARE
MUCH MORE SENSITIVE.
210 00:10:22:05 00:10:24:03 NOT ONLY DO THEY
RECORD VIBRATIONS,
211 00:10:24:05 00:10:26:03 BUT THEY CAN MEASURE
EARTHQUAKE STRENGTH, DURATION,
212 00:10:26:05 00:10:28:07 AND ALSO DETERMINE
THE EARTHQUAKE'S LOCATION
213 00:10:28:09 00:10:29:17 ALMOST IMMEDIATELY.
214 00:10:30:25 00:10:32:14 *IN 1935,*
215 00:10:32:16 00:10:35:06 *CALIFORNIA GEOPHYSICIST*
CHARLES RICHTER
216 00:10:35:08 00:10:37:21 *COMBINED THE MEASURE*
OF GROUND MOTION
217 00:10:37:23 00:10:40:21 *WITH THE DISTANCE FROM*
THE EARTHQUAKE'S EPICENTER
218 00:10:40:23 00:10:42:10 *TO YIELD A VALUE*
219 00:10:42:12 00:10:45:08 *REPRESENTING THE TOTAL*
AMOUNT OF ENERGY RELEASED
220 00:10:45:10 00:10:46:22 *DURING AN EARTHQUAKE.*
221 00:10:46:24 00:10:50:04 *HE CALLED THIS*

THE MAGNITUDE OF THE QUAKE.

222 00:10:51:23 00:10:53:21 *THE SCALE*
THAT RICHTER DEVISED

223 00:10:53:23 00:10:57:14 *RUNS FROM MAGNITUDE*
MINUS-2 TO INFINITY,

224 00:10:57:16 00:10:59:02 *ALTHOUGH*
SEISMOLOGISTS BELIEVE

225 00:10:59:04 00:11:01:03 *THAT ROCKS CAN, AT MOST,*

226 00:11:01:05 00:11:04:05 *ONLY STORE ELASTIC ENERGY*
EQUIVALENT TO MAGNITUDE 9

227 00:11:04:07 00:11:05:19 *BEFORE THEY SNAP.*

228 00:11:07:09 00:11:10:20 *THE SMALLEST TREMORS THAT*
CAN BE DISCERNED BY HUMANS,

229 00:11:10:22 00:11:13:20 *FEELING LIKE THE RUMBLING*
OF A PASSING TRAIN,

230 00:11:13:22 00:11:17:08 *MEASURE ABOUT 2.5*
ON THE RICHTER SCALE.

231 00:11:17:10 00:11:18:24 *A MAGNITUDE OF 4*

232 00:11:18:26 00:11:21:24 *IS EQUIVALENT TO*
THE AMOUNT OF ENERGY RELEASED

233 00:11:21:26 00:11:24:09 *BY 1,000 TONS*
OF EXPLOSIVES.

234 00:11:24:11 00:11:26:08 *A MAGNITUDE*
JUST ABOVE 8

235 00:11:26:10 00:11:29:10 *REPRESENTS ABOUT*
AS MUCH ENERGY

236 00:11:29:12 00:11:33:10 *AS PRODUCED BY 200*
1-MEGATON NUCLEAR BOMBS.

237 00:11:36:24 00:11:39:21 *THE REASON FOR*
THE HUGE JUMPS IN ENERGY

238 00:11:39:23 00:11:41:21 *BETWEEN ONE UNIT*
AND THE NEXT

239 00:11:41:23 00:11:43:07 *ON THE RICHTER SCALE*

240 00:11:43:09 00:11:45:23 *IS THAT EACH UNIT*
OF MAGNITUDE

241 00:11:45:25 00:11:47:26 *INCREASES LOGARITHMICALLY*

242 00:11:47:28 00:11:52:22 *BY A FACTOR JUST OVER*
30 TIMES MORE ENERGY RELEASED.

243 00:11:52:24 00:11:56:15 FOR EXAMPLE,
A MAGNITUDE 5 EARTHQUAKE

244 00:11:56:17 00:12:00:09 RELEASES ABOUT
1/30 OF THE ENERGY

245 00:12:00:11 00:12:02:23 OF A MAGNITUDE 6
EARTHQUAKE.

246 00:12:02:25 00:12:06:15 SO TO COMPARE
A MAGNITUDE 5 EARTHQUAKE

247 00:12:06:17 00:12:10:22 WITH THE MAGNITUDE
7.1 LOMA PERADA EARTHQUAKE,

248 00:12:10:24 00:12:12:22 IT'S A FACTOR
OF ABOUT 900

249 00:12:12:24 00:12:14:22 IN TERMS OF
THE ENERGY RELEASED

250 00:12:14:24 00:12:16:19 BETWEEN
THOSE TWO EARTHQUAKES.

251 00:12:16:21 00:12:20:08 SMALL EARTHQUAKES
REALLY ARE INSIGNIFICANT

252 00:12:20:10 00:12:24:01 IN TERMS OF THE RELEASE
OF STRAIN ON THE FAULT
253 00:12:24:03 00:12:29:03 THAT IS THE CAUSE OF LARGE
DAMAGING EARTHQUAKES.
254 00:12:29:05 00:12:31:22 SMALL EARTHQUAKES
REALLY TELL YOU
255 00:12:31:24 00:12:34:22 THAT A FAULT
HAS ENOUGH STRESS ON IT
256 00:12:34:24 00:12:37:16 TO CAUSE BIGGER EARTHQUAKES.
257 00:12:37:18 00:12:40:17 *ONE OF THE HIGHEST MAGNITUDE*
EARTHQUAKES
258 00:12:40:19 00:12:41:23 *EVER RECORDED*
259 00:12:41:25 00:12:44:20 *OCCURRED IN 1964*
IN ALASKA.
260 00:12:44:22 00:12:48:21 *IT REGISTERED 8.6*
ON THE RICHTER SCALE.
261 00:12:48:23 00:12:52:05 *FORTUNATELY, VERY LARGE*
EARTHQUAKES ARE RARE.
262 00:12:52:07 00:12:54:04 *OF THE THOUSANDS*
OF QUAKES
263 00:12:54:06 00:12:56:17 *THAT OCCUR WORLDWIDE*
EACH YEAR,
264 00:12:56:19 00:12:59:16 *ONLY A HUNDRED OR SO*
ARE STRONG ENOUGH
265 00:12:59:18 00:13:02:20 *TO DESTROY*
HUMAN LIFE AND PROPERTY...
266 00:13:02:22 00:13:07:08 *AND ONLY ONE OR TWO PRODUCE*
MAJOR GEOLOGICAL CHANGES.
267 00:13:09:09 00:13:11:29 *THE MOST OBVIOUS EFFECT*
OF AN EARTHQUAKE
268 00:13:12:01 00:13:13:08 *IS JUST THAT--*
269 00:13:13:10 00:13:15:22 *THE EARTH QUAKES*
AND TREMBLES.
270 00:13:15:24 00:13:17:21 [CAR ALARMS SOUND]
271 00:13:29:16 00:13:33:14 *THERE ARE MANY DIFFERENT TYPES*
OF GROUND VIBRATIONS--
272 00:13:33:16 00:13:35:00 *THE RAPID VIBRATIONS*
273 00:13:35:02 00:13:37:12 *OF THE PRIMARY*
AND SECONDARY WAVES
274 00:13:37:14 00:13:39:12 *AND THE SLOWER*
ROLLING MOTION
275 00:13:39:14 00:13:41:29 *OF WHAT ARE CALLED*
SURFACE WAVES.
276 00:13:42:01 00:13:43:13 *NEAR THE EPICENTER,*
277 00:13:43:15 00:13:45:29 *WHERE ALL THESE VIBRATIONS*
ARE CONCENTRATED
278 00:13:46:01 00:13:47:16 *AT THE SAME LOCATION,*
279 00:13:47:18 00:13:50:27 *GROUND MOTION IS SIMILAR*
TO THE COMPLEX SEA SURFACE
280 00:13:50:29 00:13:52:13 *IN AN OCEAN STORM,*
281 00:13:52:15 00:13:55:19 *WITH WAVES OF ALL SIZES*
MIXED TOGETHER.
282 00:13:55:21 00:13:58:04 *BUT THE LONGER WAVES*
TRAVEL FASTER
283 00:13:58:06 00:14:01:20 *AND MAY NOT DIE OUT*
FOR HUNDREDS OF KILOMETERS.

284 00:14:01:22 00:14:05:19 *THE AMOUNT OF TIME IT TAKES*
TWO SUCCESSIVE WAVE CRESTS
285 00:14:05:21 00:14:07:19 *TO PASS*
A STATIONARY POINT
286 00:14:07:21 00:14:09:18 *IS CALLED*
THE WAVE'S PERIOD.
287 00:14:09:20 00:14:12:18 *FOR LONGER*
SEISMIC WAVES,
288 00:14:12:20 00:14:15:11 *THIS PERIOD MAY BE*
SEVERAL SECONDS.
289 00:14:19:14 00:14:20:27 *OTHER MATERIALS,*
INCLUDING BUILDINGS,
290 00:14:20:29 00:14:23:04 *HAVE A PERIOD*
ASSOCIATED WITH THEM.
291 00:14:23:06 00:14:25:25 *IN A STRONG*
GUST OF WIND,
292 00:14:25:27 00:14:28:18 *A SKYSCRAPER*
WILL FLEX AND BEND.
293 00:14:28:20 00:14:31:03 *THE TIME IT TAKES*
FOR THE SKYSCRAPER
294 00:14:31:05 00:14:33:19 *TO OSCILLATE*
BACK AND FORTH ONCE
295 00:14:33:21 00:14:35:20 *IS CALLED*
ITS NATURAL PERIOD.
296 00:14:37:03 00:14:40:01 *WHEN THE PERIOD*
OF A SEISMIC WAVE
297 00:14:40:03 00:14:42:23 *MATCHES THE NATURAL PERIOD*
OF A BUILDING,
298 00:14:42:25 00:14:44:22 *THE SEISMIC ENERGY*
IS SIMPLY ADDED
299 00:14:44:24 00:14:46:22 *TO THE OSCILLATION*
OF THE BUILDING,
300 00:14:46:24 00:14:48:15 *WAVE AFTER WAVE.*
301 00:14:48:17 00:14:50:15 *AS A RESULT,*
302 00:14:50:17 00:14:53:15 *THE SWAYING OF THE BUILDING*
INCREASES DRAMATICALLY.
303 00:14:53:17 00:14:56:02 *OTHER BUILDINGS*
OF DIFFERENT HEIGHTS
304 00:14:56:04 00:14:58:02 *WILL NOT BE*
SIMILARLY AFFECTED
305 00:14:58:04 00:15:00:24 *BECAUSE THEIR*
NATURAL PERIODS ARE DIFFERENT.
306 00:15:03:16 00:15:06:01 *AN EXAMPLE*
OF THIS TYPE OF AMPLIFICATION
307 00:15:06:03 00:15:08:27 *OCCURS WHEN A CHILD*
IS PUSHED ON A SWING.
308 00:15:08:29 00:15:12:28 *A GENTLE PUSH IN TIME WITH*
THE SWING'S NATURAL PERIOD
309 00:15:13:00 00:15:15:18 *SENDS THE SWING*
HIGHER AND HIGHER.
310 00:15:19:18 00:15:22:16 *IN THE 1985*
MEXICAN EARTHQUAKE,
311 00:15:22:18 00:15:24:15 *SEISMIC SURFACE*
WAVE PERIODS
312 00:15:24:17 00:15:27:20 *MATCHED THE NATURAL PERIODS*
OF MEXICO CITY BUILDINGS

313 00:15:27:22 00:15:30:04 *BETWEEN 10*
AND 14 STORIES HIGH.
314 00:15:33:09 00:15:37:08 *STRUCTURES IN THIS SIZE RANGE*
WERE SERIOUSLY DAMAGED.
315 00:15:40:15 00:15:44:09 *GIVEN THE DESTRUCTIVE POWER*
OF MANY EARTHQUAKES,
316 00:15:44:11 00:15:46:24 *GEOLOGISTS HOPE*
TO DEVELOP THE ABILITY
317 00:15:46:26 00:15:48:24 *TO FORECAST QUAKES*
IN TIME
318 00:15:48:26 00:15:52:07 *TO WARN ANY PEOPLE*
WHO MIGHT BE IN DANGER.
319 00:15:52:09 00:15:53:22 *BUT TO DO THIS*
320 00:15:53:24 00:15:55:08 *REQUIRES*
A BETTER UNDERSTANDING
321 00:15:55:10 00:15:56:29 *OF EARTHQUAKE BEHAVIOR.*
322 00:16:00:00 00:16:02:28 *ONE PASTORAL STRETCH*
OF THE SAN ANDREAS FAULT
323 00:16:03:00 00:16:05:01 *NEAR*
PARKFIELD, CALIFORNIA,
324 00:16:05:03 00:16:07:29 *HAS BEEN ESPECIALLY*
PRONE TO EARTHQUAKES.
325 00:16:08:01 00:16:09:12 *SINCE 1857,*
326 00:16:09:14 00:16:11:19 *RESIDENTS OF THIS AREA*
HAVE BEEN JOLTED
327 00:16:11:21 00:16:13:05 *BY MODERATELY*
STRONG EARTHQUAKES
328 00:16:13:07 00:16:17:16 *ON AN AVERAGE OF ONCE*
EVERY 21 TO 22 YEARS.
329 00:16:17:18 00:16:21:23 *BESIDES RECURRING AT*
FAIRLY REGULAR INTERVALS,
330 00:16:21:25 00:16:24:08 *PARKFIELD EARTHQUAKES*
ALSO RESEMBLE ONE ANOTHER
331 00:16:24:10 00:16:28:05 *IN THEIR MAGNITUDES,*
LENGTHS OF FAULT RUPTURE,
332 00:16:28:07 00:16:30:14 *AND EPICENTER LOCATIONS.*
333 00:16:32:03 00:16:33:17 *FOR THIS REASON,*
334 00:16:33:19 00:16:35:24 *THE PARKFIELD AREA SEEMS*
LIKE AN IDEAL SETTING
335 00:16:35:26 00:16:38:11 *FOR AN EARTHQUAKE*
RESEARCH PROJECT.
336 00:16:41:05 00:16:42:19 *GEOPHYSICISTS ARE USING*
337 00:16:42:21 00:16:44:21 *A SOPHISTICATED ARRAY*
OF DEVICES
338 00:16:44:23 00:16:47:26 *TO CLOSELY MONITOR*
THE ROCKS ALONG THE FAULT.
339 00:16:50:14 00:16:53:12 *THE GOAL IS*
TO SPOT ANY CHANGES
340 00:16:53:14 00:16:55:26 *THAT MIGHT SIGNAL*
AN IMPENDING EARTHQUAKE.
341 00:16:59:18 00:17:02:00 *EVELYN ROELOFFS*
IS THE CHIEF SCIENTIST
342 00:17:02:02 00:17:03:21 *OVERSEEING THE PARKFIELD*
343 00:17:03:23 00:17:06:02 *EARTHQUAKE*
PREDICTION EXPERIMENT.
344 00:17:07:13 00:17:10:22 THE PARKFIELD EXPERIMENT

HAS THREE GOALS.

345 00:17:10:24 00:17:15:05 ONE GOAL IS TO TRY TO ISSUE
A SHORT-TERM PREDICTION

346 00:17:15:07 00:17:16:21 OF THE PARKFIELD EARTHQUAKE.

347 00:17:16:23 00:17:18:17 AND THAT WOULD,
IF SUCCESSFUL,

348 00:17:18:19 00:17:20:02 BE THE FIRST TIME

349 00:17:20:04 00:17:23:11 WE'VE EVER DONE SOMETHING
LIKE THAT IN THIS COUNTRY.

350 00:17:23:13 00:17:26:11 THE SECOND GOAL
IS TO RECORD THE DETAILS

351 00:17:26:13 00:17:28:11 OF THE EARTHQUAKE
GENERATION PROCESS.

352 00:17:28:13 00:17:31:12 THE THIRD GOAL IS TO TAKE
ADVANTAGE OF THE FACT

353 00:17:31:14 00:17:33:12 THAT WE'LL HAVE
A MODERATE EARTHQUAKE,

354 00:17:33:14 00:17:36:10 TO RECORD SOME OF THE EFFECTS
OF THE EARTHQUAKE,

355 00:17:36:12 00:17:38:24 SUCH AS THE AMOUNT
OF SHAKING THAT OCCUR

356 00:17:38:26 00:17:40:14 AT DIFFERENT DISTANCES
FROM THE FAULT.

357 00:17:41:27 00:17:43:24 *ONE OF THE MOST*
FUNDAMENTAL ASPECTS

358 00:17:43:26 00:17:45:10 *OF THE PARKFIELD*
EXPERIMENT

359 00:17:45:12 00:17:46:25 *FOCUSES*
ON THE STRUCTURE

360 00:17:46:27 00:17:49:11 *OF THE SAN ANDREAS*
FAULT ITSELF.

361 00:17:49:13 00:17:52:11 *TO LEARN MORE*
ABOUT THIS STRUCTURE,

362 00:17:52:13 00:17:56:24 *GEOPHYSICISTS HAVE SET UP*
THE VIBRACISE PROJECT.

363 00:17:57:28 00:18:00:10 *AT THE HEART*
OF THIS EFFORT

364 00:18:00:12 00:18:02:21 *IS A SPECIALLY-EQUIPPED*
TRUCK

365 00:18:02:23 00:18:04:04 *THAT SHAKES THE GROUND,*

366 00:18:04:06 00:18:06:04 *TRIGGERING WAVES*
OF SEISMIC ENERGY.

367 00:18:11:22 00:18:13:07 *RADIATING INTO THE EARTH,*

368 00:18:13:09 00:18:16:10 *THE SEISMIC WAVES MOVE*
AT DIFFERENT VELOCITIES

369 00:18:16:12 00:18:19:13 *THROUGH DIFFERENT*
ROCK TYPES.

370 00:18:19:15 00:18:21:12 *ANALYSIS OF*
THE VELOCITY CHANGES

371 00:18:21:14 00:18:24:25 *MAKES IT POSSIBLE TO*
UNRAVEL THE INTRICACIES

372 00:18:24:27 00:18:27:24 *OF THE SUBSURFACE*
GEOLOGIC STRUCTURE.

373 00:18:30:02 00:18:32:22 AS THE WAVES
PENETRATE THE EARTH,

374 00:18:32:24 00:18:34:21 THEY ARE REFLECTED

AND REFRACTED
375 00:18:34:23 00:18:36:06 OFF THE VARIOUS
ROCK LAYERS.
376 00:18:36:08 00:18:39:09 AND BY MEASURING
FIRST THE DIRECT WAVE,
377 00:18:39:11 00:18:41:24 WHICH TRAVELS
DIRECTLY FROM THE SOURCE
378 00:18:41:26 00:18:42:27 TO RECEIVERS,
379 00:18:42:29 00:18:44:23 WE CAN GET
THE ROCKS' VELOCITY.
380 00:18:44:25 00:18:46:08 THEN BY LOOKING
381 00:18:46:10 00:18:48:17 AT THE LATER-ARRIVING
REFLECTED AND REFRACTED
382 00:18:48:19 00:18:50:00 SCATTER WAVES,
383 00:18:50:02 00:18:52:23 WE CAN SEE POSSIBLY
WHERE THE STRUCTURE CHANGES
384 00:18:52:25 00:18:56:10 AND WHERE THE LAYERING
BENEATH THE EARTH IS.
385 00:18:57:26 00:18:59:09 *WITH AN UNDERSTANDING*
386 00:18:59:11 00:19:02:08 *OF THE GEOLOGIC STRUCTURE*
OF THE FAULT ZONE,
387 00:19:02:10 00:19:04:08 *GEOPHYSICISTS SET UP*
OTHER EXPERIMENTS
388 00:19:04:10 00:19:06:24 *TO MEASURE MOVEMENT*
ALONG THE FAULT.
389 00:19:06:26 00:19:09:10 *ONE DEVICE*
THAT CAN DETECT MOVEMENT
390 00:19:09:12 00:19:11:26 *IN A VERY SPECIFIC*
LOCALIZED AREA
391 00:19:11:28 00:19:15:08 *IS CALLED*
A CREEP METER.
392 00:19:15:10 00:19:18:08 *EACH CREEP METER*
CONSISTS OF A WIRE
393 00:19:18:10 00:19:19:23 *STRETCHED*
ACROSS THE FAULT
394 00:19:19:25 00:19:21:07 *BETWEEN*
TWO FIXED POINTS.
395 00:19:21:09 00:19:23:20 *WHENEVER*
THE FAULT SLIPS,
396 00:19:23:22 00:19:27:04 *THE LENGTH OF WIRE BETWEEN*
THE TWO POINTS CHANGES,
397 00:19:27:06 00:19:30:03 *RECORDING THE AMOUNT*
OF MOTION ALONG THE FAULT.
398 00:19:33:25 00:19:35:22 *ALTHOUGH*
THE CREEP METER
399 00:19:35:24 00:19:38:02 *ONLY COVERS ABOUT*
A 10-METER ZONE,
400 00:19:38:04 00:19:40:12 *IT RUNS AT VERY*
HIGH SENSITIVITY
401 00:19:40:14 00:19:41:22 *AND CONTINUOUSLY MONITORS*
402 00:19:41:24 00:19:44:06 *ANY FAULT MOTION*
AT THE SURFACE.
403 00:19:46:17 00:19:49:16 *TO DERIVE THE SAME*
KINDS OF INFORMATION
404 00:19:49:18 00:19:52:07 *AS PROVIDED*
BY A CREEP METER

405 00:19:52:09 00:19:54:08 *BUT OVER A WIDER AREA,*
406 00:19:54:10 00:19:55:18 *GEOPHYSICISTS*
USE WHAT'S KNOWN
407 00:19:55:20 00:19:56:28 *AS AN ALIGNMENT-ARRAY.*
408 00:19:57:00 00:19:59:21 *THIS INVOLVES*
SETTING UP MARKERS,
409 00:19:59:23 00:20:02:20 *THEN CONDUCTING SURVEYS*
ACROSS THE SAN ANDREAS FAULT
410 00:20:02:22 00:20:05:07 *TO DETERMINE*
THE LOCAL SLIP RATE,
411 00:20:05:09 00:20:07:07 *THE WIDTH OF*
THE SLIP ZONES,
412 00:20:07:09 00:20:11:04 *AND PATTERNS OF DEFORMATION*
NEAR THE FAULT TRACE.
413 00:20:13:29 00:20:15:15 180 DEGREES,
414 00:20:15:17 00:20:16:28 11 MINUTES,
415 00:20:17:00 00:20:19:20 3.0 SECONDS.
416 00:20:19:22 00:20:23:03 ES-2, 180 DEGREES,
24 MINUTES...
417 00:20:23:05 00:20:26:05 *THE ALIGNMENT-ARRAY SURVEYS*
ARE ALSO USEFUL
418 00:20:26:07 00:20:29:05 *IN HELPING SCIENTISTS*
DETERMINE THE BEST PLACES
419 00:20:29:07 00:20:30:28 *TO INSTALL*
CREEP METERS.
420 00:20:31:00 00:20:34:13 THE ALIGNMENT-ARRAY IS
SIMILAR TO THE CREEP METER
421 00:20:34:15 00:20:36:14 IN THAT IT'S
MEASURING FAULT SLIP
422 00:20:36:16 00:20:38:14 RIGHT AT
THE SURFACE TRACE.
423 00:20:38:16 00:20:40:00 HOWEVER, THE CREEP METER
424 00:20:40:02 00:20:43:04 IS A CONTINUOUS
MONITORING DEVICE
425 00:20:43:06 00:20:46:04 FOR THE CENTER
OF THAT SLIP AREA,
426 00:20:46:06 00:20:47:18 WHEREAS THE ALIGNMENT-ARRAY
427 00:20:47:20 00:20:50:04 GOES MUCH FARTHER AWAY
FROM THE FAULT
428 00:20:50:06 00:20:53:06 TO BE SURE WE'RE NOT MISSING
SOME IMPORTANT SLIP
429 00:20:53:08 00:20:56:06 ON AUXILIARY FRACTURES
OUT TO THE SIDE.
430 00:20:56:08 00:20:58:06 THE ALIGNMENT-ARRAY,
OF COURSE, IS ONLY--
431 00:20:58:08 00:21:01:06 WE ONLY GET DATA
WHEN WE MAKE SURVEYS,
432 00:21:01:08 00:21:04:06 WHEREAS THE CREEP METER
CAN BE RUN CONTINUOUSLY,
433 00:21:04:08 00:21:07:07 AND WE CAN LOOK
AT THAT EVERY DAY
434 00:21:07:09 00:21:10:07 TO SEE HOW MUCH
THE CENTER OF THIS ZONE
435 00:21:10:09 00:21:11:18 HAS ACTUALLY MOVED.
436 00:21:14:08 00:21:16:27 *ANOTHER IMPORTANT COMPONENT*
IN THE PARKFIELD EFFORT

437 00:21:16:29 00:21:19:20 *TO BETTER UNDERSTAND*
THE MECHANICS OF FAULTING
438 00:21:19:22 00:21:21:21 *IS THE GEODOMETER.*
439 00:21:21:23 00:21:23:24 *THIS SHOOTS*
RAYS OF LASER LIGHT
440 00:21:23:26 00:21:27:22 *AT 18 REFLECTORS SET UP*
LIKE THE SPOKES OF A WHEEL
441 00:21:27:24 00:21:29:25 *ON THE HILLS*
AROUND PARKFIELD.
442 00:21:29:27 00:21:31:12 WE'VE PUT REFLECTORS
443 00:21:31:14 00:21:33:06 AT DIFFERENT POINTS
AROUND THE VALLEY,
444 00:21:33:08 00:21:35:17 AND WE TAKE
MEASUREMENTS TO THOSE.
445 00:21:35:19 00:21:38:19 WE KEEP TRACK OF HOW LONG
IT TAKES THAT LIGHT
446 00:21:38:21 00:21:41:25 TO GO OUT TO THAT REFLECTOR
AND COME BACK
447 00:21:41:27 00:21:43:24 WITH SOPHISTICATED EQUIPMENT
AND COMPUTERS.
448 00:21:43:26 00:21:46:08 BY KNOWING HOW FAST
THE LIGHT TRAVELS
449 00:21:46:10 00:21:49:19 AND KNOWING HOW LONG IT TOOK
TO GET THERE AND BACK,
450 00:21:49:21 00:21:51:19 WE CAN CALCULATE
A MEASUREMENT
451 00:21:51:21 00:21:54:04 TO WITHIN A FRACTION
OF A MILLIMETER
452 00:21:54:06 00:21:55:15 ON A 9-KILOMETER LINE
453 00:21:55:17 00:21:57:00 WHEN CONDITIONS ARE GOOD.
454 00:21:57:02 00:21:59:18 *THIS NETWORK OF LIGHT*
IS SO SENSITIVE
455 00:21:59:20 00:22:01:02 *THAT IT CAN DETECT*
456 00:22:01:04 00:22:03:02 *THE SLIGHTEST*
BENDING OF ROCKS
457 00:22:03:04 00:22:05:12 *ALONG THE FAULT ZONE.*
458 00:22:05:14 00:22:08:19 *THE GEODOMETER'S SYSTEM*
COVERS A MUCH BROADER AREA
459 00:22:08:21 00:22:10:12 *THAN EITHER*
A CREEP METER
460 00:22:10:14 00:22:13:16 *OR AN ALIGNMENT-ARRAY*
SURVEY.
461 00:22:13:18 00:22:16:18 THEY'RE ALL DESIGNED TO LOOK
AT THE SAME KIND OF THING
462 00:22:16:20 00:22:19:20 WITH DIFFERENT SENSITIVITIES
AND AT DIFFERENT SCALES,
463 00:22:19:22 00:22:22:04 SO THEY ALL CONTRIBUTE
TO AN UNDERSTANDING
464 00:22:22:06 00:22:24:16 OF THE MECHANICS
OF THE FAULTING.
465 00:22:26:06 00:22:28:03 *BEFORE THE NEXT*
PARKFIELD EARTHQUAKE,
466 00:22:28:05 00:22:29:19 *SCIENTISTS HOPE TO SEE*
467 00:22:29:21 00:22:32:00 *AN ACCELERATION*
OF THE SLIP THAT OCCURS
468 00:22:32:02 00:22:35:20 *ON THE SAN ANDREAS FAULT*

BETWEEN EARTHQUAKES.

469 00:22:35:22 00:22:38:14 *IF THAT ACCELERATION*
TAKES PLACE AT THE SURFACE,

470 00:22:38:16 00:22:42:13 *IT CAN BE DETECTED DIRECTLY*
BY A CREEP METER,

471 00:22:42:15 00:22:44:25 *BUT GEOLOGISTS*
MUST USE OTHER TECHNIQUES

472 00:22:44:27 00:22:47:25 *TO DETECT DEEP MOVEMENT*
ALONG THE FAULT

473 00:22:47:27 00:22:51:26 *THAT DOES NOT APPEAR*
AS SLIP AT THE SURFACE.

474 00:22:55:24 00:22:58:10 *AS STRESS*
ACCUMULATES IN THE EARTH,

475 00:22:58:12 00:23:01:01 *GROUND WATER WILL RESPOND*
BY RISING OR FALLING.

476 00:23:01:03 00:23:04:01 *THIS CAN BE MEASURED*
IN WATER WELLS

477 00:23:04:03 00:23:06:16 *INSTALLED BY THE PARKFIELD*
RESEARCH TEAM.

478 00:23:14:26 00:23:16:22 HOLDING 65.

479 00:23:16:24 00:23:19:20 *A SUDDEN DROP*
IN WATER LEVEL

480 00:23:19:22 00:23:21:02 *IS SOMETIMES OBSERVED*

481 00:23:21:04 00:23:23:00 *AS THE GROUND*
SWELLS AND CRACKS

482 00:23:23:02 00:23:25:26 *IN THE DAYS*
PRECEDING AN EARTHQUAKE.

483 00:23:28:09 00:23:30:17 *SEISMOLOGISTS*
STUDYING PARKFIELD

484 00:23:30:19 00:23:33:04 *ARE ALSO INTERESTED*
IN MEASURING FORESHOCKS--

485 00:23:33:06 00:23:36:01 *THE SEISMIC ACTIVITY THAT*
PRECEDES AN EARTHQUAKE.

486 00:23:36:03 00:23:38:15 *TO DO THIS*

487 00:23:38:17 00:23:41:00 *REQUIRES A DETAILED NETWORK*
OF SEISMOMETERS

488 00:23:41:02 00:23:43:29 *WHICH THE PARKFIELD TEAM*
HAS SET UP.

489 00:23:45:23 00:23:49:01 *TINY EARTHQUAKES*
ARE COMMON OCCURRENCES

490 00:23:49:03 00:23:51:21 *ALONG MOST ACTIVE FAULTS,*

491 00:23:51:23 00:23:54:06 *BUT SHORTLY*
BEFORE A LARGE QUAKE,

492 00:23:54:08 00:23:55:20 *THE FREQUENCY*

493 00:23:55:22 00:23:57:29 *AND DISTRIBUTION*
OF SMALL SHOCKS MAY CHANGE.

494 00:23:58:01 00:24:01:17 BEING THE PERSON WHO
LOOKS AT THE SEISMICITY,

495 00:24:01:19 00:24:03:10 I'M EXPECTING
TO SEE CHANGES

496 00:24:03:12 00:24:05:21 IN THE PATTERNS
OF THE EARTHQUAKE.

497 00:24:05:23 00:24:08:00 EARTHQUAKES OCCUR
IN THE FAULT ZONE

498 00:24:08:02 00:24:09:25 IN A FAIRLY
COMPLICATED MANNER.

499 00:24:09:27 00:24:11:24 SOME PLACES,
THE ACTIVITY'S SHALLOW.
500 00:24:11:26 00:24:13:10 SOME PLACES,
ACTIVITY'S DEEP.
501 00:24:13:12 00:24:15:18 AS WE GET MORE
DETAILED INFORMATION
502 00:24:15:20 00:24:16:29 ABOUT THE FAULT ZONE,
503 00:24:17:01 00:24:20:01 WE SEE KNOTS OR CLUSTERS
THAT ARE ACTIVE.
504 00:24:20:03 00:24:23:00 WE EXPECT TO SEE
THAT LARGER EARTHQUAKES
505 00:24:23:02 00:24:25:14 WILL START AT
MAGNITUDE 2s, 2 1/2, 3s
506 00:24:25:16 00:24:28:03 AND WILL MIGRATE
DOWN THE FAULT ZONE
507 00:24:28:05 00:24:31:03 TOWARDS THE AREA
THAT WILL FAIL FIRST.
508 00:24:31:05 00:24:35:01 THIS IS THE PATTERN
SEEN IN '34 AND '66
509 00:24:35:03 00:24:37:29 AND THAT WE'RE KEEPING
A VERY CLOSE EYE ON
510 00:24:38:01 00:24:41:06 TO SEE IF THAT KIND
OF ACTIVITY OCCURS AGAIN.
511 00:24:42:17 00:24:44:23 *IN THE CASE OF*
THE PARKFIELD EXPERIMENT,
512 00:24:44:25 00:24:46:22 *THE DATA*
OBTAINED IN THE FIELD
513 00:24:46:24 00:24:49:09 *ARE THEN REGULARLY*
TRANSMITTED BY SATELLITE
514 00:24:49:11 00:24:51:09 *TO THE U.S.*
GEOLOGICAL SURVEY
515 00:24:51:11 00:24:54:08 *IN MENLO PARK, CALIFORNIA,*
FOR ANALYSIS.
516 00:24:55:25 00:24:58:23 *HERE THE DATA*
ARE MONITORED BY SCIENTISTS
517 00:24:58:25 00:25:00:13 *FOR ANY*
UNUSUAL ACTIVITY.
518 00:25:00:15 00:25:03:09 *DEPENDING ON THE EXTENT*
OF SUCH ACTIVITY,
519 00:25:03:11 00:25:04:24 *THE PARKFIELD*
RESEARCH TEAM
520 00:25:04:26 00:25:06:09 *MAY DECLARE ANY ONE*
521 00:25:06:11 00:25:08:19 *OF FOUR PREARRANGED*
ALERT LEVELS.
522 00:25:09:26 00:25:11:23 COULD YOU
FILL US IN?
523 00:25:11:25 00:25:14:08 *THESE ALERT LEVELS*
INDICATE THE PROBABILITY
524 00:25:14:10 00:25:17:08 *OF A SIZABLE EARTHQUAKE*
OCCURRING AT PARKFIELD
525 00:25:17:10 00:25:20:06 *WITHIN THE FOLLOWING*
72 HOURS.
526 00:25:20:08 00:25:24:08 THE SEISMIC ACTIVITY
FOR THE PAST TWO DAYS
IS SHOWN HERE.
527 00:25:24:10 00:25:27:29 WE HAVE SOME EARTHQUAKES

REPRESENTING AN INCREASE
IN ONGOING ACTION.

528 00:25:28:01 00:25:31:13 *IF AND WHEN THERE IS*
A HIGH-LEVEL ALERT,

529 00:25:31:15 00:25:33:06 *THE U.S.G.S. WILL INFORM*

530 00:25:33:08 00:25:35:26 *THE CALIFORNIA OFFICE*
OF EMERGENCY SERVICES,

531 00:25:35:28 00:25:39:10 *WHICH WILL THEN ISSUE*
A WARNING TO THE PUBLIC.

532 00:25:39:12 00:25:41:00 *THIS WARNING SIGNIFIES*

533 00:25:41:02 00:25:45:27 *THAT THE SEISMOLOGISTS AT*
THE U.S.G.S. IN MENLO PARK

534 00:25:45:29 00:25:49:01 *BELIEVE THERE IS*
AT LEAST A 30% CHANCE

535 00:25:49:03 00:25:51:11 *A MAGNITUDE 6*
OR HIGHER EARTHQUAKE

536 00:25:51:13 00:25:55:01 *WILL OCCUR IN PARKFIELD*
DURING THE NEXT 72 HOURS.

537 00:25:57:27 00:26:00:07 *THERE ARE NO GUARANTEES,*
OF COURSE,

538 00:26:00:09 00:26:03:00 *THE PARKFIELD RESEARCH TEAM*
WILL BE ABLE TO PREDICT

539 00:26:03:02 00:26:05:16 *THE NEXT SIZABLE QUAKE*
IN THAT REGION

540 00:26:05:18 00:26:07:21 *IN TIME*
TO ISSUE A WARNING,

541 00:26:07:23 00:26:09:26 *BUT MEMBERS*
OF THE PARKFIELD TEAM

542 00:26:09:28 00:26:12:14 *BELIEVE THAT*
THEIR PROJECT IS VALUABLE

543 00:26:12:16 00:26:16:00 *EVEN IF A SHORT-TERM*
WARNING IS NOT ISSUED.

544 00:26:16:02 00:26:19:27 IT'S ENABLING US TO RECORD
THE DETAILS OF FAULT SLIP

545 00:26:19:29 00:26:25:03 TO A DEGREE THAT THEY'VE
NEVER BEEN RECORDED BEFORE,

546 00:26:25:05 00:26:27:25 AND IF THERE ARE PRECURSORS
RECORDED BY INSTRUMENTS

547 00:26:27:27 00:26:30:11 THAT AREN'T INVOLVED
IN THE ALERT-LEVEL SCHEME,

548 00:26:30:13 00:26:32:10 WE'LL DETECT THEM
AFTER THE FACT

549 00:26:32:12 00:26:34:25 AND MAYBE USE THEM
TO PREDICT

550 00:26:34:27 00:26:37:27 THE NEXT MODERATE EARTHQUAKE
IN CALIFORNIA.

551 00:26:37:29 00:26:39:09 *IN THE MEANTIME,*

552 00:26:39:11 00:26:41:25 *THE DATA-RECORDING DEVICES*
AT PARKFIELD

553 00:26:41:27 00:26:44:09 *AND THE SCIENTISTS*
AT MENLO PARK

554 00:26:44:11 00:26:47:01 *MAINTAIN*
THEIR SEISMIC VIGIL

555 00:26:55:12 00:26:57:10 ALONG
THE SAN ANDREAS FAULT

556 00:26:57:12 00:26:59:24 AND ON ACTIVE FAULTS

ALL OVER THE WORLD,
557 00:26:59:26 00:27:01:08 BLOCKS
OF THE EARTH'S CRUST
558 00:27:01:10 00:27:03:24 CONTINUOUSLY TRY
TO SLIDE PAST ONE ANOTHER.
559 00:27:03:26 00:27:06:10 THIS CAUSES THE ROCKS
IN A FAULT ZONE
560 00:27:06:12 00:27:07:19 TO BEND AND DEFORM,
561 00:27:07:21 00:27:09:12 ACCUMULATING
TREMENDOUS TECTONIC STRESS
562 00:27:09:14 00:27:10:26 IN THE PROCESS.
563 00:27:10:28 00:27:13:09 EVENTUALLY,
THIS MASSIVE STORE OF ENERGY
564 00:27:13:11 00:27:15:24 WILL EXCEED THE BREAKING
STRENGTH OF THE ROCKS,
565 00:27:15:26 00:27:17:08 TRIGGERING AN EARTHQUAKE.
566 00:27:17:10 00:27:19:24 THERE'S NO DOUBT
THIS WILL OCCUR.
567 00:27:19:26 00:27:22:23 THE PRINCIPAL QUESTIONS
ARE WHEN AND HOW STRONG
568 00:27:22:25 00:27:24:24 THE RESULTING EARTHQUAKE
WILL BE.
569 00:27:24:26 00:27:27:10 WHILE EARTHQUAKE RESEARCH
CONTINUES,
570 00:27:27:12 00:27:29:09 THE HOPES OF A RELIABLE
571 00:27:29:11 00:27:30:24 SHORT-TERM
FORECASTING SYSTEM
572 00:27:30:26 00:27:32:24 ARE STILL
PROBABLY DECADES AWAY.
573 00:27:32:26 00:27:35:22 THIS TASK IS COMPLICATED
BY THE FACT
574 00:27:35:24 00:27:37:21 THAT EACH FAULT
IS UNIQUE,
575 00:27:37:23 00:27:40:06 AND SUCCESSIVE EARTHQUAKES
ON A GIVEN FAULT
576 00:27:40:08 00:27:41:28 CAN VARY CONSIDERABLY.
577 00:27:42:00 00:27:43:06 IN THE MEANTIME,
578 00:27:43:08 00:27:44:23 THERE ARE TANGIBLE STEPS
579 00:27:44:25 00:27:47:08 WE CAN TAKE
TO PREPARE OURSELVES
580 00:27:47:10 00:27:49:22 FOR THE EARTHQUAKES
THAT WILL SURELY OCCUR.
581 00:27:49:24 00:27:51:07 NATURE HAS FORCED US
582 00:27:51:09 00:27:53:22 TO LIVE WITH THESE
SUDDEN RELEASES OF ENERGY,
583 00:27:53:24 00:27:56:06 BUT KNOWLEDGE
GIVES US THE POWER
584 00:27:56:08 00:27:59:11 AND THE CHANCE
TO SURVIVE THEM.
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