

1 00:30:41:22 00:30:45:04 Annenberg Media
2 00:30:45:06 00:31:29:11 §
3 00:31:29:13 00:31:32:04 CAPTIONING MADE POSSIBLE BY
SOUTHERN CALIFORNIA CONSORTIUM
4 00:31:39:04 00:31:41:04 FOR MOST OF HUMAN HISTORY,
5 00:31:41:06 00:31:44:04 THE POWER OF CIVILIZATION
HAS BEEN HUMAN POWER.
6 00:31:44:06 00:31:47:03 H.G. WELLS DESCRIBES LIFE
DURING THIS PERIOD
7 00:31:47:05 00:31:49:23 IN HIS BOOK,
OUTLINE IN HISTORY.
8 00:31:49:25 00:31:52:02 "WHERE A WEIGHT
HAD TO BE LIFTED,
9 00:31:52:04 00:31:53:18 "MEN LIFTED IT--
10 00:31:53:20 00:31:55:19 "WHERE A ROCK
HAD TO BE QUARRIED,
11 00:31:55:21 00:31:57:04 "MEN CHIPPED IT OUT--
12 00:31:57:06 00:31:59:03 "WHERE A FIELD
HAD TO BE PLOWED,
13 00:31:59:05 00:32:01:03 "MAN AND OXEN PLOWED IT.
14 00:32:01:05 00:32:04:02 "THE ROMAN EQUIVALENT
OF THE STEAMSHIP
WAS THE GALLEY,
15 00:32:04:04 00:32:06:09 WITH ITS BANKS
OF SWEATING ROWERS."
16 00:32:06:11 00:32:07:23 FOR THOUSANDS OF YEARS,
17 00:32:07:25 00:32:09:08 ACROSS
CULTURES AND CONTINENTS,
18 00:32:09:10 00:32:12:09 HUMAN SURVIVAL AND
THE ADVANCEMENT OF SOCIETY
19 00:32:12:11 00:32:14:10 HAVE DEPENDED
ON PHYSICAL STRENGTH.
20 00:32:14:12 00:32:17:03 IN FACT, IT WAS NOT
UNTIL THE 18th CENTURY--
21 00:32:17:05 00:32:19:18 ABOUT THE TIME OF
THE AMERICAN REVOLUTION--
22 00:32:19:20 00:32:22:02 THAT A CHANGE
BEGAN TO TAKE PLACE.
23 00:32:22:04 00:32:24:03 IT'S INTERESTING
THAT THIS CHANGE
24 00:32:24:05 00:32:27:04 IS ALSO REFERRED
TO BY HISTORIANS
AS A REVOLUTION--
25 00:32:27:06 00:32:28:19 "THE INDUSTRIAL
REVOLUTION."
26 00:32:28:21 00:32:30:04 IT BEGAN IN ENGLAND
27 00:32:30:06 00:32:32:27 WHERE A SERIES OF SIMPLE
MECHANICAL INVENTIONS
28 00:32:32:29 00:32:34:11 MADE IT POSSIBLE
29 00:32:34:13 00:32:37:01 TO HARNESS THE POWER
OF GRAVITY AND HEAT.
30 00:32:37:03 00:32:39:00 AT FIRST,
THIS POWER-DRIVEN MACHINERY
31 00:32:39:02 00:32:41:29 WAS TOO CRUDE AND
INEFFICIENT TO BE OF MUCH USE,
32 00:32:42:01 00:32:44:00 BUT AS

33 00:32:44:02 THE 19th CENTURY UNFOLDED
 00:32:45:16 AND MECHANICAL
 34 00:32:45:18 TECHNOLOGY IMPROVED,
 00:32:48:02 IT BECAME OBVIOUS
 35 00:32:48:04 THAT MUCH OF THE WORK
 00:32:50:17 DONE BY HUMANS
 36 00:32:50:19 AND THEIR ANIMALS
 00:32:53:16 COULD BE DONE FASTER,
 37 00:32:53:18 CHEAPER, AND OFTEN BETTER
 00:32:54:18 BY MACHINES.
 38 00:32:54:20 00:32:57:00 HUMAN POWER
 "WAS NEEDED NOW
 39 00:32:57:02 00:32:59:28 "ONLY WHERE CHOICE
 AND INTELLIGENCE
 HAD TO BE EXERCISED.
 40 00:33:00:02 00:33:01:13 "THE DRUDGE,
 41 00:33:01:15 00:33:04:05 "ON WHOM ALL PREVIOUS
 CIVILIZATIONS HAD RESTED,
 42 00:33:04:07 00:33:06:05 "THE CREATURE
 OF MERE OBEDIENCE,
 43 00:33:06:07 00:33:09:24 HAD BECOME UNNECESSARY
 TO THE WELFARE OF MANKIND."
 44 00:33:09:26 00:33:13:07 TODAY WE'VE COME TO REALIZE
 THAT OUR QUALITY OF LIFE
 45 00:33:13:09 00:33:16:08 AND OUR FUTURE EXISTENCE
 ON THIS PLANET
 46 00:33:16:10 00:33:18:08 DEPEND ON HOW WE EXERCISE
 47 00:33:18:10 00:33:21:01 THIS HUMAN POWER
 OF CHOICE AND INTELLIGENCE.
 48 00:33:21:03 00:33:22:16 DURING THE LAST CENTURY,
 49 00:33:22:18 00:33:25:16 AND LARGELY AS A RESULT OF
 THE INDUSTRIAL REVOLUTION,
 50 00:33:25:18 00:33:28:00 MUCH OF THE EARTH'S SUPPLY
 OF GEOLOGIC RESOURCES
 51 00:33:28:02 00:33:29:16 HAS BEEN SEVERELY DEPLETED
 52 00:33:29:18 00:33:31:16 BY THE ALMOST
 INSATIABLE APPETITE
 53 00:33:31:18 00:33:33:16 OF OUR
 ENERGY-HUNGRY LIFESTYLE
 54 00:33:33:18 00:33:35:00 AND A GROWING POPULATION.
 55 00:33:35:02 00:33:37:02 IN FACT,
 MOST GEOLOGIC FUELS,
 56 00:33:37:04 00:33:40:00 INCLUDING OIL, NATURAL GAS,
 COAL, AND URANIUM
 57 00:33:40:02 00:33:42:00 ARE CONSIDERED
 TO BE NONRENEWABLE.
 58 00:33:42:02 00:33:45:00 DEPOSITS OF THESE MATERIALS
 FORM EXTREMELY SLOWLY
 59 00:33:45:02 00:33:47:29 WHEN COMPARED TO
 A HUMAN TIME SCALE.
 60 00:33:48:01 00:33:49:29 AT PRESENT RATES
 OF CONSUMPTION,
 61 00:33:50:01 00:33:52:14 WE CAN EXPECT
 THAT SOME TIME
 62 00:33:52:16 00:33:54:14 IN THE NEXT FEW GENERATIONS
 63 00:33:54:16 00:33:56:15 THESE MATERIALS

64 00:33:56:17 WILL BE UNAVAILABLE
00:33:59:00 OR SIMPLY
TOO COSTLY TO USE.

65 00:33:59:02 00:34:01:29 SO AT THIS CRITICAL TIME
IN OUR HISTORY,

66 00:34:02:01 00:34:04:14 HUMAN POWER AGAIN
BECOMES VITALLY IMPORTANT.

67 00:34:04:16 00:34:05:29 CREATIVE AND
ENTERPRISING SCIENTISTS

68 00:34:06:01 00:34:08:14 ARE USING THEIR KNOWLEDGE
AND TALENTS

69 00:34:08:16 00:34:11:13 TO SEARCH FOR
NEW FORMS OF ENERGY.

70 00:34:11:15 00:34:12:29 IN THE MEANTIME,

71 00:34:13:01 00:34:14:24 GEOLOGISTS ARE
WORKING TO LOCATE,

72 00:34:14:26 00:34:16:20 AND TO MORE
EFFICIENTLY DEVELOP,

73 00:34:16:22 00:34:17:29 EXISTING SOURCES OF ENERGY.

74 00:34:19:24 00:34:22:13 *OF ALL EARTH'S
GEOLOGIC RESOURCES,*

75 00:34:22:15 00:34:26:00 *NONE IS MORE PRIZED,
NOR IN SHORTER SUPPLY,*

76 00:34:26:02 00:34:27:18 *THAN OIL.*

77 00:34:29:03 00:34:32:00 *OIL MAY BE FOUND
IN ANCIENT MARINE STRATA*

78 00:34:32:02 00:34:34:29 *AS MUCH AS
A HALF BILLION YEARS OLD.*

79 00:34:37:01 00:34:38:27 *ALONG THE MARGINS
OF CONTINENTS,*

80 00:34:38:29 00:34:41:11 *THE SEAS TEEM WITH
MICROSCOPIC LIFE.*

81 00:34:41:13 00:34:45:11 *AS THESE ORGANISMS DIE AND
SETTLE TO THE SEA FLOOR,*

82 00:34:45:13 00:34:47:28 *THEY MAY BE BURIED
BY SEDIMENT,*

83 00:34:48:00 00:34:50:12 *WHICH PROTECTS THEM
FROM RAPID DECAY.*

84 00:34:52:15 00:34:55:12 *AS THIS ORGANIC MATTER
BECOMES MORE DEEPLY BURIED,*

85 00:34:55:14 00:34:57:27 *IT IS GRADUALLY
TRANSFORMED INTO OIL*

86 00:34:57:29 00:35:00:27 *AND NATURAL GAS
BY HEAT AND PRESSURE.*

87 00:35:00:29 00:35:04:27 *IT TYPICALLY TAKES MILLIONS
OF YEARS FOR THIS TO OCCUR.*

88 00:35:07:07 00:35:08:19 *PETROLEUM EXPLORATION*

89 00:35:08:21 00:35:10:27 *REQUIRES LOCATING
THE GEOLOGIC STRUCTURES*

90 00:35:10:29 00:35:13:26 *THAT TRAP OIL AND GAS.*

91 00:35:13:28 00:35:15:27 *THESE STRUCTURES
ARE USUALLY MARKED*

92 00:35:15:29 00:35:18:28 *BY CHANGES IN
DENSITY UNDERGROUND.*

93 00:35:19:00 00:35:21:28 *GEOLOGISTS ARE ABLE*

94 00:35:22:00 00:35:26:03 *TO DETECT THESE CHANGES
 BY BOUNCING SEISMIC WAVES
 THROUGH EARTH'S CRUST.*
 95 00:35:26:05 00:35:28:04 YOU HAVE TO KEEP IN MIND
 96 00:35:28:06 00:35:31:03 THAT DOWN IN
 THE SUBSURFACE OF THE EARTH
 97 00:35:31:05 00:35:33:03 THE ROCKS HAVE
 DIFFERENT HARDNESSES.
 98 00:35:33:05 00:35:35:03 WHEN YOU HAVE
 TWO FORMATIONS,
 99 00:35:35:05 00:35:38:15 OR TWO ROCK LAYERS THAT
 HAVE A DIFFERENT HARDNESS,
 100 00:35:38:17 00:35:40:28 AND THEY'RE IN CONTACT
 WITH EACH OTHER,
 101 00:35:41:00 00:35:43:04 YOU CAN GET
 A REFLECTION BACK--
 102 00:35:43:06 00:35:45:18 JUST LIKE LOOKING
 INTO A MIRROR,
 103 00:35:45:20 00:35:48:17 YOU GET A REFLECTION
 OF YOUR FACE,
 104 00:35:48:19 00:35:51:18 JUST LIKE THE SONOGRAM
 REFLECTS OFF THE BABY'S BODY
 105 00:35:51:20 00:35:54:17 AND RETURNS
 ITS IMAGE TO THE SURFACE.
 106 00:35:56:00 00:35:58:19 *SEISMIC WAVES ARE
 ARTIFICIALLY GENERATED*
 107 00:35:58:21 00:36:01:11 *ABOVE POTENTIAL
 OIL-BEARING ROCKS.*
 108 00:36:01:13 00:36:04:10 WE HAVE A TRUCK
 CALLED A VIBROSEIS TRUCK
 109 00:36:04:12 00:36:06:10 THAT ACTUALLY
 SHAKES THE GROUND.
 110 00:36:06:12 00:36:09:03 THE VIBROSEIS TRUCK
 WOULD SHAKE THE GROUND
 111 00:36:09:05 00:36:10:29 IN AN UP-AND-DOWN FASHION
 112 00:36:11:01 00:36:14:10 MUCH LIKE A JACKHAMMER
 ON A CONSTRUCTION SITE
 SHAKES THE GROUND.
 113 00:36:14:12 00:36:16:09 WE MAY DRILL A HOLE
 114 00:36:16:11 00:36:19:10 5 FOOT OR 200 FOOT
 DOWN INTO THE GROUND
 115 00:36:19:12 00:36:22:24 AND SET OFF 5 TO 20
 POUNDS OF DYNAMITE
 116 00:36:22:26 00:36:25:12 CREATING THAT SHOCK WAVE
 THAT WE NEED.
 117 00:36:27:00 00:36:29:26 *THESE SHOCK WAVES ARE DETECTED
 BY ELECTRONIC RECEIVERS*
 118 00:36:29:28 00:36:32:18 *KNOWN AS GEOPHONES.*
 119 00:36:32:20 00:36:35:17 *THE GEOPHONES ARE LAID OUT
 IN A LINE*
 120 00:36:35:19 00:36:39:08 *OR GRID PATTERN
 OVER THE AREA TO BE MAPPED.*
 121 00:36:39:10 00:36:42:14 *THE INFORMATION RECORDED
 BY THE GEOPHONES*
 122 00:36:42:16 00:36:44:14 *IS PROCESSED BY A COMPUTER,*
 123 00:36:44:16 00:36:47:19 *WHICH IN TURN GENERATES*

A REFLECTION SEISMOGRAM.

124 00:36:47:21 00:36:51:12 UH, YOU GOT
ABOUT 30 SECONDS.

125 00:36:51:14 00:36:54:02 WHAT YOU SEE ON
THIS REFLECTION SEISMOGRAM

126 00:36:54:04 00:36:56:02 IS A SERIES OF REFLECTIONS.

127 00:36:56:04 00:36:59:02 THOSE ARE OCCURRING
WHERE THAT SOURCE,
THAT SHOCK WAVE,

128 00:36:59:04 00:37:00:28 BOUNCES OFF
THE SUBSURFACE ROCKS

129 00:37:01:00 00:37:03:13 AND COMES BACK
TO THE SURFACE

130 00:37:03:15 00:37:05:27 AND IS RECORDED
AT THE GEOPHONES.

131 00:37:05:29 00:37:08:24 SO WE SEE IMAGES
OF THE SUBSURFACE.

132 00:37:08:26 00:37:11:23 *SEVERAL SEISMOGRAMS ARE
COMBINED TO PRODUCE MAPS*

133 00:37:11:25 00:37:15:26 *SHOWING THE DEPTHS
TO OIL-BEARING FORMATIONS.*

134 00:37:17:09 00:37:19:22 NOW THAT
SUBSURFACE DEPTH MAP

135 00:37:19:24 00:37:22:23 WOULD PORTRAY A STRUCTURE
IN THE SUBSURFACE,

136 00:37:22:25 00:37:25:23 MUCH LIKE A TOPOGRAPHIC MAP
PORTRAYS A MOUNTAIN

137 00:37:25:25 00:37:28:22 OR A STRUCTURE ON
THE SURFACE OF THE EARTH.

138 00:37:28:24 00:37:30:07 ONCE WE'VE DONE THAT,

139 00:37:30:09 00:37:33:07 IF WE ASCERTAIN THERE'S
A STRUCTURE OR TRAP THERE

140 00:37:33:09 00:37:35:21 WITH THE CAPACITY
TO HOLD HYDROCARBONS,

141 00:37:35:23 00:37:38:20 AND THE OTHER THINGS
FIT INTO THE PICTURE

142 00:37:38:22 00:37:41:05 WITH RESPECT TO SOURCE,
MIGRATION, TIMELINESS,

143 00:37:41:07 00:37:42:21 AND RESERVOIR ROCK,

144 00:37:42:23 00:37:44:21 THEN WE'D MAKE
A DETERMINATION

145 00:37:44:23 00:37:47:06 OF WHETHER THAT PROSPECT
WAS ECONOMIC.

146 00:37:47:08 00:37:50:19 IF SO, AND WE WERE ABLE
TO GET THE LAND,

147 00:37:50:21 00:37:52:19 WE'D POSSIBLY DRILL A WELL

148 00:37:52:21 00:37:55:10 AND HOPEFULLY HAVE
A LARGE DISCOVERY.

149 00:37:55:12 00:37:57:22 *ARCO'S SIGHT IN
BAKERSFIELD, CALIFORNIA*

150 00:37:57:24 00:37:59:06 *IS THOUGHT TO CONTAIN*

151 00:37:59:08 00:38:01:22 *OVER 100 MILLION
BARRELS OF OIL*

152 00:38:01:24 00:38:04:28 *IN A DEPOSIT THAT IS
ROUGHLY 38 FEET THICK*

153 00:38:05:00 00:38:07:18 *AND 2,000 FEET LONG.*

154 00:38:09:23 00:38:12:07 *ALTHOUGH MORE
THAN A THOUSAND WELLS*

155 00:38:12:09 00:38:13:18 *HAVE PIERCED
THIS RESERVOIR,*

156 00:38:13:20 00:38:16:02 *A SIGNIFICANT PORTION
OF THE OIL*

157 00:38:16:04 00:38:17:21 *STILL REMAINS UNDERGROUND.*

158 00:38:19:22 00:38:21:19 *THE OIL ACTUALLY
ISN'T CONTAINED*

159 00:38:21:21 00:38:23:04 *IN HUGE POOLS UNDERGROUND.*

160 00:38:23:06 00:38:24:19 *REALLY IT'S CONTAINED*

161 00:38:24:21 00:38:27:20 *WITHIN THESE
VERY SMALL PORE SPACES*

162 00:38:27:22 00:38:29:07 *OF SEDIMENTARY ROCKS*

163 00:38:29:09 00:38:31:07 *LIKE SANDSTONES
AND LIMESTONES.*

164 00:38:31:09 00:38:33:22 *THE FLOW OPENINGS
THROUGH THESE ROCKS*

165 00:38:33:24 00:38:35:06 *ARE REALLY QUITE SMALL,*

166 00:38:35:08 00:38:38:04 *AND IT TAKES A TREMENDOUS
AMOUNT OF PRESSURE*

167 00:38:38:06 00:38:40:19 *TO FORCE THE OIL AND GAS*

168 00:38:40:21 00:38:43:25 *THROUGH THE PORE SPACES
IN THE ROCKS.*

169 00:38:45:06 00:38:47:03 *IN A NEW, UNTAPPED FIELD,*

170 00:38:47:05 00:38:49:20 *THE NATURAL PRESSURE
OF THE FORMATION*

171 00:38:49:22 00:38:52:07 *MAY BE ENOUGH
TO DRIVE THE OIL*

172 00:38:52:09 00:38:53:22 *TO THE SURFACE,*

173 00:38:53:24 00:38:56:22 *BUT AS WELLS DRAW OIL
FROM THE GROUND,*

174 00:38:56:24 00:38:58:08 *THAT PRESSURE DROPS*

175 00:38:58:10 00:39:01:06 *AND EXTRACTION
BECOMES MORE DIFFICULT.*

176 00:39:01:08 00:39:05:00 *TYPICALLY, AS MUCH
AS 2/3 OF THE OIL
REMAINS UNDERGROUND*

177 00:39:05:02 00:39:07:16 *BECAUSE OF
THIS DROP IN PRESSURE.*

178 00:39:11:06 00:39:14:16 *BUT A NEW TECHNIQUE
CALLED HORIZONTAL DRILLING*

179 00:39:14:18 00:39:17:00 *IS NOW BEING USED
TO COAX OIL*

180 00:39:17:02 00:39:20:20 *FROM PARTIALLY
DEPLETED RESERVES.*

181 00:39:20:22 00:39:23:19 *[MARINO] THE FIRST STEP
IN PERFORATING A HORIZONTAL WELL*

182 00:39:23:21 00:39:26:05 *IS TO RUN LONG
PIECES OF PIPE*

183 00:39:26:07 00:39:28:19 *CALLED PERFORATING GUNS
INTO THE WELL.*

184 00:39:28:21 00:39:31:03 *THESE PERFORATING GUNS
CONTAIN JET CHARGES*

185 00:39:31:05 00:39:35:01 *THAT WILL BLOW HOLES
IN THE PIPE.*

186 00:39:35:03 00:39:37:29 THE GUNS ARE RUN
 INTO THE WELL
 187 00:39:38:01 00:39:40:14 ON THE END OF WELL TUBING,
 188 00:39:40:16 00:39:42:12 AND ONCE THEY'RE
 PROPERLY POSITIONED
 189 00:39:42:14 00:39:45:05 ACROSS FROM THE FORMATIONS
 WE WANT TO PERFORATE,
 190 00:39:45:07 00:39:46:12 THEY'RE DETONATED
 191 00:39:46:14 00:39:49:01 BY USING WATER PRESSURE
 IN THE WELL
 192 00:39:49:03 00:39:50:25 TO IGNITE A FIRING HEAD
 193 00:39:50:27 00:39:52:25 THAT STARTS
 THE FIRING CHAIN
 194 00:39:52:27 00:39:55:13 ALL THE WAY DOWN THE GUNS.
 195 00:39:57:14 00:39:59:03 *[GUNFIRE]*
 196 00:39:59:05 00:40:00:11 *[EXPLOSION]*
 197 00:40:00:13 00:40:03:02 THE GUNS FIRE OVER
 A 1,300-FOOT INTERVAL
 198 00:40:03:04 00:40:05:01 IN A SPLIT SECOND.
 199 00:40:08:04 00:40:09:17 *HORIZONTAL DRILLING*
TECHNIQUES
 200 00:40:09:19 00:40:12:01 *ALLOW ENGINEERS TO*
PENETRATE SHALLOW DEPOSITS
 201 00:40:12:03 00:40:15:03 *THAT WOULD HAVE BEEN*
TOO EXPENSIVE TO TAP
 202 00:40:15:05 00:40:17:09 *USING VERTICAL METHODS.*
 203 00:40:18:20 00:40:20:17 *THIS LONE*
HORIZONTAL DRILL RIG
 204 00:40:20:19 00:40:21:26 *HAS PRODUCED*
 205 00:40:21:28 00:40:24:06 *APPROXIMATELY*
900 BARRELS PER DAY
 206 00:40:24:08 00:40:26:06 *FOR THE LAST SEVEN MONTHS.*
 207 00:40:26:08 00:40:28:21 *TO ACHIEVE*
THE SAME PRODUCTION RATE
 208 00:40:28:23 00:40:30:06 *WITH CONVENTIONAL*
DRILLING TECHNIQUES
 209 00:40:30:08 00:40:33:06 *WOULD REQUIRE*
FOUR TIMES AS MANY WELLS
 210 00:40:33:08 00:40:35:20 *AT A 40% INCREASE*
IN COST.
 211 00:40:37:14 00:40:38:22 HORIZONTAL DRILLING
 212 00:40:38:24 00:40:41:07 WILL BE USED
 MORE AND MORE IN THE FUTURE
 213 00:40:41:09 00:40:43:16 TO TRY TO GET
 THE LAST BIT
 214 00:40:43:18 00:40:46:01 OUT OF A LOT
 OF OIL FIELDS.
 215 00:40:46:03 00:40:48:18 SOME PEOPLE ESTIMATE
 THAT WITHIN 10 YEARS
 216 00:40:48:20 00:40:51:02 ABOUT A THIRD
 OF THE WELLS DRILLED
 217 00:40:51:04 00:40:52:17 ARE GOING
 TO BE HORIZONTAL.
 218 00:40:52:19 00:40:54:02 AS THE TECHNOLOGY IMPROVES,
 219 00:40:54:04 00:40:56:02 THE COST OF
 HORIZONTAL DRILLING

220 00:40:56:04 00:40:57:17 WILL BECOME
 MORE COMPETITIVE
 221 00:40:57:19 00:41:01:01 WITH THE CONVENTIONAL
 VERTICAL WELLS ALSO.
 222 00:41:01:03 00:41:02:17 AND, UH, ULTIMATELY,
 223 00:41:02:19 00:41:06:03 I THINK IT'S GOING TO MAKE
 A BIG CONTRIBUTION
 224 00:41:06:05 00:41:09:23 TO THE RECOVERY OF OIL
 THROUGHOUT THE WORLD.
 225 00:41:11:19 00:41:14:12 *WHILE THE POTENTIAL
 OF HORIZONTAL DRILLING*
 226 00:41:14:14 00:41:16:00 *REMAINS PROMISING,*
 227 00:41:16:02 00:41:18:28 *SCIENTISTS HAVE ADOPTED
 EVER MORE EXOTIC TECHNIQUES*
 228 00:41:19:00 00:41:21:12 *IN THE QUEST
 FOR GEOLOGIC RESOURCES.*
 229 00:41:25:19 00:41:29:00 *THROUGH A PROCESS
 KNOWN AS REMOTE SENSING,*
 230 00:41:29:02 00:41:30:29 *SATELLITES CIRCLING
 HIGH ABOVE EARTH*
 231 00:41:31:01 00:41:32:14 *GATHER DATA*
 232 00:41:32:16 00:41:35:04 *FROM LARGE AREAS OF
 THE PLANET'S SURFACE.*
 233 00:41:36:27 00:41:38:08 THIS IS IN CONTRAST
 234 00:41:38:10 00:41:40:23 TO THE WAY
 WE DID IT BEFORE.
 235 00:41:40:25 00:41:43:15 WE'D MAP A LITTLE
 POSTAGE STAMP AREA HERE
 236 00:41:43:17 00:41:45:00 AND ANOTHER AREA HERE.
 237 00:41:45:02 00:41:46:16 THEN SOMEONE WOULD COLLECT
 238 00:41:46:18 00:41:48:14 ALL THESE POSTAGE STAMPS
 OF INFORMATION,
 239 00:41:48:16 00:41:50:29 DRAW LINES BETWEEN THEM,
 AND SAY,
 240 00:41:51:01 00:41:53:16 "O.K., THIS IS
 THE INTEGRATED MAP
 241 00:41:53:18 00:41:56:01 OF OKLAHOMA
 OR THE UNITED STATES."
 242 00:41:56:03 00:41:59:01 AND IN THE COURSE
 OF DOING THAT CONNECTION
 243 00:41:59:03 00:42:00:15 BETWEEN THE POSTAGE STAMPS,
 244 00:42:00:17 00:42:02:00 WE'D QUITE OFTEN LOSE
 245 00:42:02:02 00:42:04:15 THE KIND OF INFORMATION
 AND INSIGHTS
 246 00:42:04:17 00:42:07:00 THAT WE WERE
 REALLY TRYING TO GAIN
 247 00:42:07:02 00:42:10:16 BY VIRTUE OF--OF INTEGRATING
 OR OF COMPILING
 248 00:42:10:18 00:42:13:20 A LARGE MAP
 OF A LARGE AREA.
 249 00:42:13:22 00:42:16:07 SO WHAT REMOTE SENSING
 HAS DONE,
 250 00:42:16:09 00:42:18:14 OR SATELLITE REMOTE SENSING
 PARTICULARLY,
 251 00:42:18:16 00:42:20:15 IS GIVEN US A CHANCE
 252 00:42:20:17 00:42:22:14 TO LOOK AT

253 00:42:22:16 THE INTERRELATIONSHIP
 00:42:25:18 BETWEEN WIDELY
 SEPARATED FEATURES
 254 00:42:25:20 00:42:28:03 AND SEE THOSE IN A WAY
 255 00:42:28:05 00:42:31:02 THAT WE'VE NOT BEEN
 ABLE TO SEE BEFORE.
 256 00:42:32:12 00:42:33:23 SATELLITES DETECT
 THESE FEATURES
 257 00:42:33:25 00:42:37:00 BY MEASURING
 THE ELECTROMAGNETIC RADIATION
 258 00:42:37:02 00:42:40:04 EMITTED OR REFLECTED
 BY EARTH'S SURFACE.
 259 00:42:41:15 00:42:42:28 ELECTROMAGNETIC RADIATION
 260 00:42:43:00 00:42:46:24 CONSISTS OF A CONTINUOUS
 SPECTRUM OF ENERGY.
 261 00:42:46:26 00:42:48:09 VISIBLE LIGHT
 262 00:42:48:11 00:42:50:29 COMPRISES ONE SMALL PART
 OF THIS SPECTRUM,
 263 00:42:51:01 00:42:53:29 WHICH ALSO INCLUDES
 HIGHER-ENERGY GAMMA RAYS,
 264 00:42:54:01 00:42:56:24 X-RAYS, AND
 ULTRA-VIOLET RADIATION.
 265 00:42:59:15 00:43:02:12 AT THE OTHER END
 OF THE SPECTRUM
 266 00:43:02:14 00:43:04:29 LIE LOWER-ENERGY
 RADIO WAVES,
 267 00:43:05:01 00:43:06:22 MICROWAVES, AND
 INFRARED RADIATION.
 268 00:43:10:14 00:43:14:12 HUMAN VISION IS RESTRICTED
 TO BANDS OF VISIBLE LIGHT.
 269 00:43:14:14 00:43:15:25 SATELLITES, HOWEVER,
 270 00:43:15:27 00:43:18:14 CAN PEER INTO THE REALM
 OF THE INVISIBLE
 271 00:43:18:16 00:43:20:15 AND SEE THE FULL RANGE
 272 00:43:20:17 00:43:22:13 OF THE ELECTROMAGNETIC
 SPECTRUM.
 273 00:43:24:15 00:43:27:21 ANOTHER ASPECT
 OF THE VALUE OF THE DATA
 274 00:43:27:23 00:43:30:20 ARE YOU'RE RECORDING DATA
 IN DISCRETE SPECTRAL BANDS.
 275 00:43:30:22 00:43:33:19 A LOT OF THESE BANDS
 WE DON'T EVEN SEE.
 276 00:43:33:21 00:43:36:20 SO WHAT WE HAVE
 AVAILABLE TO US, THEN,
 277 00:43:36:22 00:43:38:07 IS INFORMATION IN AREAS
 278 00:43:38:09 00:43:41:18 THAT ARE BEYOND,
 SPECTRALLY BEYOND,
 WHAT WE CAN SEE
 279 00:43:41:20 00:43:44:20 WITH OUR OWN SENSORS,
 OUR OWN EYES.
 280 00:43:46:22 00:43:49:19 ALONG WITH
 THEIR WIDE FIELD OF VIEW,
 281 00:43:49:21 00:43:51:06 THIS ABILITY OF SATELLITES
 282 00:43:51:08 00:43:53:16 TO DETECT DIFFERENT
 WAVELENGTHS OF LIGHT
 283 00:43:53:18 00:43:54:29 PROVIDES SCIENTISTS

284 00:43:55:01 00:43:57:27 *WITH A UNIQUE PERSPECTIVE
ON OUR PLANET.*

285 00:43:57:29 00:43:59:26 SO WE REALLY WERE CREATED

286 00:43:59:28 00:44:02:10 TO TAKE ADVANTAGE
OF THAT TECHNOLOGY,

287 00:44:02:12 00:44:05:11 AND THE IDEA WAS
THAT THE COMPANY

288 00:44:05:13 00:44:06:26 WOULD BE
MULTI-DISCIPLINARY.

289 00:44:06:28 00:44:09:01 WE'D HAVE GEOLOGISTS
AND FORESTERS

290 00:44:09:03 00:44:10:27 AND OCEANOGRAPHERS
AND CLIMATOLOGISTS

291 00:44:10:29 00:44:14:11 AND PHYSICISTS
AND SO ON AND SO FORTH.

292 00:44:14:13 00:44:17:26 THAT IDEA HAS PERSISTED.

293 00:44:17:28 00:44:19:26 ALMOST FROM DAY ONE,

294 00:44:19:28 00:44:22:26 AN AWFUL LOT
OF OUR BUSINESS

295 00:44:22:28 00:44:25:25 CAME FROM GEOLOGY, PARTICULARLY
GEOLOGIC EXPLORATION.

296 00:44:25:27 00:44:29:27 IT'S AN AREA
FOR WHICH REMOTE SENSING

297 00:44:29:29 00:44:32:23 IS--IS JUST
PERFECTLY SUITED.

298 00:44:32:25 00:44:34:21 IN GEOLOGY,
AS YOU WOULD EXPECT,

299 00:44:34:23 00:44:36:23 THE BULK OF OUR CLIENTS,

300 00:44:36:25 00:44:40:15 HAVE BEEN OIL AND GAS
EXPLORATION COMPANIES,

301 00:44:40:17 00:44:41:29 MINERAL EXPLORATION
COMPANIES,

302 00:44:42:01 00:44:43:15 AND PEOPLE IN GROUPS

303 00:44:43:17 00:44:46:27 WHO ARE INVOLVED IN
GROUND WATER EXPLORATION.

304 00:44:49:03 00:44:51:16 *RECENTLY,
A GROUP OF OIL COMPANIES*

305 00:44:51:18 00:44:53:16 *ASKED THE EARTH
SATELLITE CORPORATION*

306 00:44:53:18 00:44:54:27 *TO INVESTIGATE
THE POTENTIAL*

307 00:44:54:29 00:44:59:07 *FOR OIL AND GAS RESERVES
IN PAKISTAN.*

308 00:44:59:09 00:45:02:06 THE IDEA WAS TO GET
AN INTEGRATED NOTION

309 00:45:02:08 00:45:05:09 OF OIL AND GAS OCCURRENCE
IN PAKISTAN,

310 00:45:05:11 00:45:07:25 OF COURSE,
WITH THE HOPE OF--

311 00:45:07:27 00:45:10:24 1--FINDING EXTENSIONS
OF THINGS THAT WERE KNOWN,

312 00:45:10:26 00:45:13:08 AND 2--UH, HOPEFULLY
FINDING AREAS

313 00:45:13:10 00:45:14:24 THAT HAD POTENTIAL

314 00:45:14:26 00:45:18:10 THAT REALLY HAD NOT BEEN,
UH, EXAMINED IN ANY DETAIL

315 00:45:18:12 00:45:20:29 OR DRILLED,
 FOR THAT MATTER.
 316 00:45:22:10 00:45:24:04 *THE DATA*
GATHERED BY SATELLITE
 317 00:45:24:06 00:45:26:06 *WAS BEAMED BACK TO EARTH*
 318 00:45:26:08 00:45:28:24 *AS A STREAM OF*
COMPUTERIZED INFORMATION.
 319 00:45:28:26 00:45:32:05 *IT DID NOT LOOK LIKE*
A PICTURE OF PAKISTAN
 320 00:45:32:07 00:45:33:18 *UPON ITS ARRIVAL.*
 321 00:45:33:20 00:45:38:21 BECAUSE WE RECORD
 ALL OF THE INFORMATION
 322 00:45:38:23 00:45:40:25 AS A BUNCH OF NUMBERS,
 323 00:45:40:27 00:45:43:09 WE CAN THEN
 USE THOSE NUMBERS
 324 00:45:43:11 00:45:45:25 AND APPLY MATHEMATICAL
 TECHNIQUES TO THEM
 325 00:45:45:27 00:45:47:07 WHICH ENHANCE
 THE INFORMATION,
 326 00:45:47:09 00:45:49:22 OR COMBINE THE INFORMATION
 IN DIFFERENT WAYS
 327 00:45:49:24 00:45:52:07 TO GET A PRODUCT WE WANT.
 328 00:45:52:09 00:45:55:06 YOU RECKON THOSE
 ARE LITTLE FIELD
 BOUNDARIES THERE?
 329 00:45:55:08 00:45:57:24 DIFFERENT FEATURES
 ON THE EARTH
 330 00:45:57:26 00:45:59:24 ARE SENSITIVE
 TO DIFFERENT PORTIONS
 331 00:45:59:26 00:46:02:01 OF THE ELECTROMAGNETIC
 SPECTRUM.
 332 00:46:02:03 00:46:05:14 THEREFORE, IF YOU WERE
 INTERESTED IN VEGETATION,
 333 00:46:05:16 00:46:07:17 WE'D USE A DIFFERENT
 BAND COMBINATION.
 334 00:46:07:19 00:46:09:14 IF YOU'RE INTERESTED
 IN URBAN AREAS,
 335 00:46:09:16 00:46:12:15 WE'D SELECT A BAND
 COMBINATION BASED ON THAT--
 336 00:46:12:17 00:46:15:08 WHATEVER YOU WANT TO
 GET OUT OF THE IMAGERY.
 337 00:46:15:10 00:46:18:21 *BY CREATING A COMPOSITE PICTURE*
FROM INDIVIDUAL IMAGES,
 338 00:46:18:23 00:46:21:07 *THE IMAGING TEAM*
IS ABLE TO SEE
 339 00:46:21:09 00:46:23:06 *GEOLOGIC FEATURES AND*
REGIONAL RELATIONSHIPS
 340 00:46:23:08 00:46:25:02 *THAT WERE NOT APPARENT*
 341 00:46:25:04 00:46:27:02 *WHEN THE AREA*
WAS STUDIED
 342 00:46:27:04 00:46:30:14 *ON A PICTURE*
BY PICTURE BASIS.
 343 00:46:30:16 00:46:33:14 *PRODUCING A MOSAIC*
IS A COMPLEX TASK.
 344 00:46:33:16 00:46:35:29 *COLORS AND CONTRAST*
MUST BE MATCHED

345 00:46:36:01 00:46:38:12 *TO MINIMIZE
THE PATCHWORK EFFECT.*
346 00:46:40:01 00:46:42:18 ONCE ALL THAT IS DONE,
347 00:46:42:20 00:46:44:17 WE TAKE THAT
COMPOSITE PRINT--
348 00:46:44:19 00:46:47:02 THE MOSAIC OF
ALL THE SCENES--
349 00:46:47:04 00:46:51:07 WE COPY THOSE
IN A COPY CAMERA.
350 00:46:51:09 00:46:55:07 THEN WE MAKE
AN ENLARGED PRINT
FOR THE CART LAB
351 00:46:55:09 00:46:57:23 SO THAT THEY
CAN ADD ANNOTATION.
352 00:46:57:25 00:47:00:08 THEN WE MAKE
A FINAL PRINT
353 00:47:00:10 00:47:03:08 THAT HAS THE LEGEND
AND ALL THE INFORMATION
354 00:47:03:10 00:47:05:20 THE GEOLOGIST WOULD LIKE
TO OVERLAY ON THAT.
355 00:47:05:22 00:47:08:20 *WHEN GEOLOGISTS EXAMINED
THE FEATURES OF PAKISTAN
ON A LARGE SCALE,
THEY WERE QUITE SURPRISED.*
356 00:47:08:22 00:47:10:05
357 00:47:10:07 00:47:12:06
358 00:47:14:04 00:47:17:02 THERE ARE A SERIES
OF FOLDS IN PAKISTAN
359 00:47:17:04 00:47:19:17 THAT LOOK LIKE
WRINKLES UNDER YOUR EYE
360 00:47:19:19 00:47:22:07 AFTER YOU'VE BEEN UP
TOO LONG.
361 00:47:22:09 00:47:23:22 THE CONCLUSION WAS
362 00:47:23:24 00:47:25:22 THAT THESE
REALLY MARKED AREAS
363 00:47:25:24 00:47:28:21 WHERE WE HAD THICKER
SEQUENCES OF SEDIMENT--
364 00:47:28:23 00:47:31:07 THAT IS,
THESE WERE OLD BASINS.
365 00:47:31:09 00:47:33:22 WE CONCLUDED
WE WERE REALLY LOOKING
366 00:47:33:24 00:47:36:23 AT A RATHER COMPLEX MARGIN
OF AN OLD CONTINENT.
367 00:47:38:10 00:47:41:08 *THE FACT THAT THE MOSAIC
REVEALED FEATURES
AND RELATIONSHIPS
THAT HAD NOT BEEN DETECTED
FROM THE ANALYSIS
OF SINGLE IMAGES,
OR FROM
FIELD INVESTIGATIONS,
PROMPTED GEOLOGISTS
TO SEEK ANSWERS
TO QUESTIONS THAT MIGHT
NEVER HAVE BEEN ASKED.*
374 00:47:53:17 00:47:57:00 AND AS WE DELVED
INTO THE LITERATURE,
375 00:47:57:02 00:47:59:29 WE FOUND THAT

376 00:48:00:03 THERE WAS GOOD EVIDENCE
 00:48:03:00 THAT, IN FACT,
 THE INDIAN PLATE ITSELF
 377 00:48:03:02 00:48:06:16 HAD BUMPED INTO EURASIA UP
 ON THE NORTHWESTERN CORNER
 378 00:48:06:18 00:48:08:22 AND THEN ROTATED
 COUNTERCLOCKWISE.
 379 00:48:10:07 00:48:12:04 SO INSIGHTS
 LIKE THAT BECOME,
 380 00:48:12:06 00:48:17:03 UH, JUST ABSOLUTELY,
 UH, INVALUABLE
 381 00:48:17:05 00:48:21:17 IN TRYING TO--TO UNRAVEL
 THE DEFORMATIONAL HISTORY
 382 00:48:21:19 00:48:23:18 THAT MAY BEAR ON
 383 00:48:23:20 00:48:25:18 WHERE HYDROCARBONS
 MIGHT BE, UH,
 384 00:48:25:20 00:48:27:20 BE LOCATED TODAY.
 385 00:48:27:22 00:48:30:05 WE WERE ABLE TO COME UP
 386 00:48:30:07 00:48:32:19 WITH A NUMBER
 OF OTHER AREAS
 387 00:48:32:21 00:48:34:19 THAT HAVE NOT BEEN EXAMINED
 388 00:48:34:21 00:48:37:07 THAT LOOK LIKE THEY HAVE
 VERY LARGE POTENTIAL.
 389 00:48:37:09 00:48:39:15 CREATIVE TECHNIQUES,
 LIKE REFLECTIVE SEISMOLOGY,
 390 00:48:39:17 00:48:40:20 HORIZONTAL DRILLING,
 391 00:48:40:22 00:48:42:16 AND SATELLITE
 REMOTE SENSING,
 392 00:48:42:18 00:48:44:16 NOT ONLY MAKE
 THE DEVELOPMENT
 393 00:48:44:18 00:48:47:15 OF EXISTING OIL AND
 GAS RESERVES MORE EFFICIENT,
 394 00:48:47:17 00:48:49:02 THEY ALSO ALLOW GEOLOGISTS
 395 00:48:49:04 00:48:52:02 TO SEARCH FOR NEW OIL FIELDS
 MORE EFFECTIVELY.
 396 00:48:52:04 00:48:55:01 BUT AS POWERFUL AS
 THESE TECHNOLOGIES ARE,
 397 00:48:55:03 00:48:58:01 THEY REPRESENT ONLY
 A SHORT-TERM SOLUTION
 398 00:48:58:03 00:48:59:15 TO OUR ENERGY PROBLEMS.
 399 00:48:59:17 00:49:01:15 AND REGARDLESS
 OF HOW EFFICIENT
 400 00:49:01:17 00:49:03:15 OUR OIL-EXTRACTION
 CAPABILITIES BECOME,
 401 00:49:03:17 00:49:05:16 THE WIDESPREAD USE
 OF PETROLEUM
 402 00:49:05:18 00:49:07:02 AND OTHER FOSSIL FUELS
 403 00:49:07:04 00:49:09:12 WILL CONTINUE
 TO AGGRAVATE A NUMBER
 404 00:49:09:14 00:49:12:08 OF SERIOUS ENVIRONMENTAL
 AND PUBLIC HEALTH PROBLEMS.
 405 00:49:12:10 00:49:13:22 THE SIMPLE,
 INESCAPABLE FACT
 406 00:49:13:24 00:49:16:22 IS THAT THE WORLD'S
 SUPPLY OF PETROLEUM
 407 00:49:16:24 00:49:18:16 IS FINITE AND NONRENEWABLE.

408 00:49:18:18 00:49:21:16 THE BEST ESTIMATE
OF GLOBAL OIL RESERVES
409 00:49:21:18 00:49:23:17 INDICATES THAT
WE'VE ALREADY USED
410 00:49:23:19 00:49:26:16 ABOUT HALF OF THE WORLD'S
COMMERCIALY AVAILABLE OIL,
411 00:49:26:18 00:49:29:00 AND OIL THAT'S NOW FORMING
IN SEDIMENTARY ROCKS
412 00:49:29:02 00:49:32:01 WON'T BE AVAILABLE
FOR MILLIONS OF YEARS.
413 00:49:32:03 00:49:35:02 IT'S SAFE TO SAY
MANY OF US LIVING TODAY
414 00:49:35:04 00:49:38:15 WILL SEE AN END TO
THE WIDESPREAD USE OF PETROLEUM
415 00:49:38:17 00:49:41:04 FOR TRANSPORTATION AND
FOR GENERATING ELECTRICITY.
416 00:49:41:06 00:49:42:29 SHRINKING SUPPLIES,
RISING PRICES,
417 00:49:43:01 00:49:46:14 AND THE ENVIRONMENTAL COST
OF USING FOSSIL FUELS
418 00:49:46:16 00:49:49:29 HAS PROMPTED A SEARCH
FOR OTHER FORMS OF ENERGY,
419 00:49:50:01 00:49:52:14 AND HERE, HUMAN POWER
HAS AGAIN RESPONDED
420 00:49:52:16 00:49:54:28 TO ALTER THE COURSE
OF OUR FUTURE
421 00:49:55:00 00:49:57:15 BY CREATING NEW MACHINES
AND NEW TECHNOLOGIES
422 00:49:57:17 00:50:00:00 TO CAPTURE THE INTENSITY
OF THE SUN,
423 00:50:00:02 00:50:02:14 HARNESS THE FORCE
OF THE WIND,
424 00:50:02:16 00:50:05:14 AND USE THE HEAT
OF THE EARTH'S INTERIOR.
425 00:50:05:16 00:50:08:14 THESE ENERGY SOURCES
ARE FUNDAMENTALLY DIFFERENT
FROM FOSSIL FUELS.
426 00:50:08:16 00:50:11:00 THEY PRODUCE LITTLE
OR NO POLLUTION,
427 00:50:11:02 00:50:13:15 AND THEY ARE, FOR
THE MOST PART, RENEWABLE.
428 00:50:13:17 00:50:16:14 THESE SOURCES OF ENERGY
HAVE THE POTENTIAL
429 00:50:16:16 00:50:20:08 TO PLAY A VITAL ROLE
FOR GENERATIONS TO COME.
430 00:50:20:10 00:50:22:08 *ONE ALTERNATIVE
TO FOSSIL FUELS*
431 00:50:22:10 00:50:25:07 *WHICH HAS BEEN IN USE
FOR SOME TIME*
432 00:50:25:09 00:50:26:17 *IS HYDROPOWER.*
433 00:50:29:07 00:50:31:21 *WATER RUSHING
THROUGH PASSAGEWAYS IN DAMS*
434 00:50:31:23 00:50:35:24 *SPINS ENORMOUS TURBINES
WHICH GENERATE ELECTRICITY.*
435 00:50:38:25 00:50:41:29 *A MORE RECENT DEVELOPMENT
IS THE WIND FARM.*

436 00:50:42:01 00:50:44:01 VAST NUMBERS
OF AIR TURBINES,

437 00:50:44:03 00:50:45:16 STRETCHED ACROSS HILLSIDES,

438 00:50:45:18 00:50:48:00 CONVERT THE FORCE
OF THE WIND

439 00:50:48:02 00:50:49:17 INTO ELECTRIC POWER.

440 00:50:51:19 00:50:53:27 LIGHT FROM THE SUN

441 00:50:53:29 00:50:56:23 IS YET ANOTHER ALTERNATIVE
SOURCE OF ENER.

442 00:50:56:25 00:50:59:17 WITH THE USE OF
PHOTOVOLTAIC CELLS,

443 00:50:59:19 00:51:02:04 SUNLIGHT
GENERATES ELECTRICITY.

444 00:51:02:06 00:51:06:14 IT IS ALSO USED TO HEAT
WATER AND BUILDINGS.

445 00:51:08:01 00:51:10:28 EACH OF THESE ALTERNATIVES
TO FOSSIL FUELS

446 00:51:11:00 00:51:13:29 IS DRIVEN BY EARTH'S
EXTERNAL HEAT ENGINE--

447 00:51:14:01 00:51:15:29 THE ENERGY OF THE SUN

448 00:51:16:01 00:51:18:29 TRANSFORMED INTO WIND,
LIGHT, OR RUNNING WATER.

449 00:51:21:16 00:51:23:14 BUT EARTH'S INTERNAL
HEAT ENGINE

450 00:51:23:16 00:51:26:04 CAN PROVIDE
ENERGY AS WELL.

451 00:51:26:06 00:51:28:19 HOT ROCK
IN THE SHALLOW CRUST

452 00:51:28:21 00:51:32:08 HAS BEEN TAPPED TO
PRODUCE GEOTHERMAL POWER.

453 00:51:32:10 00:51:34:08 IN VOLCANIC REGIONS,
GEOTHERMAL ENERGY

454 00:51:34:10 00:51:37:07 IS USED TO HEAT
THOUSANDS OF HOMES

455 00:51:37:09 00:51:40:01 AND PLACES OF WORK.
MORE COMMONLY, HOWEVER,

456 00:51:40:03 00:51:44:12 IT IS USED
TO GENERATE ELECTRICITY.

457 00:51:44:14 00:51:46:28 GEOTHERMAL SIGHTS
AROUND THE WORLD--

458 00:51:47:00 00:51:48:15 THERE'S QUITE A FEW.

459 00:51:48:17 00:51:51:15 THERE'S 250 PLANTS
OPERATING IN 16 COUNTRIES

460 00:51:51:17 00:51:53:28 ON 6 CONTINENTS,
SO IT'S WIDESPREAD.

461 00:51:54:00 00:51:55:27 THE FIRST GEOTHERMAL
POWER PLANT

462 00:51:55:29 00:51:58:27 THAT ACTUALLY PRODUCED
ELECTRICITY, LIKE WE ARE HERE,

463 00:51:58:29 00:52:01:12 WAS IN 1904
IN LARBRODELLO, ITALY,

464 00:52:01:14 00:52:04:12 SO IT'S AN OLD TECHNOLOGY
THAT'S BEEN APPLIED

465 00:52:04:14 00:52:06:12 IN A LOT OF OTHER PLACES.

466 00:52:06:14 00:52:09:13 THE UNITED STATES
DID NOT START UNTIL RECENTLY

467 00:52:09:15 00:52:11:27 WITH THE INCREASE
IN ENERGY COSTS.

468 00:52:14:14 00:52:15:27 *THE GEOTHERMAL ENERGY
CONTAINED*

469 00:52:15:29 00:52:18:27 *IN THE UPPER 5 KILOMETERS
OF EARTH'S CRUST*

470 00:52:18:29 00:52:21:27 *IS SAID TO BE
40 MILLION TIMES GREATER*

471 00:52:21:29 00:52:25:28 *THAN THE ENERGY CONTAINED
IN OIL AND GAS RESERVES,*

472 00:52:26:00 00:52:28:28 *BUT ONLY A SMALL FRACTION
OF THIS ENERGY*

473 00:52:29:00 00:52:31:15 *CAN BE EXPLOITED
ECONOMICALLY.*

474 00:52:34:15 00:52:36:29 *ONE AREA THAT
IS BEING EXPLORED*

475 00:52:37:01 00:52:38:10 *FOR ITS
GEOTHERMAL POTENTIAL*

476 00:52:38:12 00:52:41:25 *IS THE IMPERIAL VALLEY
OF CALIFORNIA.*

477 00:52:41:27 00:52:44:26 *THE CRUST IS
RELATIVELY THICK
IN MOST PLACES,*

478 00:52:44:28 00:52:47:11 *BUT THIS AREA
WHERE WE ARE TODAY--*

479 00:52:47:13 00:52:49:19 *IT'S THIN--
ONLY ABOUT 18,000 FEET.*

480 00:52:49:21 00:52:53:18 *SO WE'RE VERY CLOSE
TO THE LIQUID ROCK
WITHIN THE EARTH.*

481 00:52:53:20 00:52:56:18 *THAT HEAT IS VERY CLOSE
TO THE SURFACE,*

482 00:52:56:20 00:52:59:19 *AND WATER IN THE GROUND
CONTACTS THAT MAGMA,*

483 00:52:59:21 00:53:03:04 *BRINGS HEAT TO THE SURFACE,
AND WE CAN PRODUCE IT.*

484 00:53:03:06 00:53:06:02 *IT'S IN AREAS LIKE THIS
WHERE WE CAN USE IT.*

485 00:53:06:04 00:53:09:02 *IF YOU DRILL DEEP ENOUGH
ANYWHERE IN THE WORLD,*

486 00:53:09:04 00:53:10:26 *YOU CAN GET THE HEAT.*

487 00:53:10:28 00:53:14:10 *HERE WE CAN DRILL
SHALLOW AND GET THE HEAT.*

488 00:53:14:12 00:53:16:25 *THE MAGMA BENEATH
THE IMPERIAL VALLEY*

489 00:53:16:27 00:53:18:10 *HEATS UP GROUND WATER,*

490 00:53:18:12 00:53:21:11 *CAUSING IT TO RISE
THROUGH THE CRUST.*

491 00:53:21:13 00:53:23:25 *AS THE GROUND WATER
REACHES THE SURFACE,*

492 00:53:23:27 00:53:27:16 *IT CAN FLASH,
OR INSTANTANEOUSLY
VAPORIZE TO STEAM.*

493 00:53:27:18 00:53:30:15 *THIS STEAM IS THEN
USED TO DRIVE TURBINES,*

494 00:53:30:17 00:53:32:19 *WHICH GENERATE ELECTRICITY.*

495 00:53:34:28 00:53:37:09 BUT THE GROUND WATER
CONTAINS SALTS,
496 00:53:37:11 00:53:40:05 WHICH CORRODE TURBINES
AND CLOG PIPES.
497 00:53:41:26 00:53:44:08 THESE DISSOLVED SALTS
CALLED BRINE
498 00:53:44:10 00:53:48:01 MUST FIRST BE REMOVED
TO PURIFY THE STEAM.
499 00:53:48:03 00:53:50:02 AS IT ENTERS THE PLANT,
500 00:53:50:04 00:53:52:17 IT GOES INTO
A LARGE SEPARATION VESSEL
501 00:53:52:19 00:53:54:28 WHERE WE TAKE STEAM
OFF THE TOP
502 00:53:55:00 00:53:56:24 AND BRINE OFF THE BOTTOM.
503 00:53:56:26 00:54:01:02 THIS FIRST STEAM COMES OFF
AT ABOUT 110-120 POUNDS.
504 00:54:01:04 00:54:03:19 IT GOES TO
A HIGH-PRESSURE TURBINE.
505 00:54:03:21 00:54:06:05 IT SPINS THE TURBINE
AND MAKE ELECTRICITY.
506 00:54:06:07 00:54:08:06 THE BRINE THAT COMES OFF
507 00:54:08:08 00:54:11:22 GOES TO ANOTHER SEPARATION
WHERE MORE STEAM IS REMOVED
508 00:54:11:24 00:54:14:22 DOWN TO ALMOST ATMOSPHERIC
PRESSURE LIKE WE BREATHE.
509 00:54:14:24 00:54:19:08 THAT STEAM THEN GOES INTO
ANOTHER PART OF A TURBINE,
510 00:54:19:10 00:54:20:25 MAKES MORE ELECTRICITY.
511 00:54:20:27 00:54:24:10 IT'S THEN CONDENSED
AND PUT BACK WITH THE BRINE
512 00:54:24:12 00:54:26:25 OR PUT INTO
A COOLING TOWER
513 00:54:26:27 00:54:29:08 TO GENERATE COOLING
FOR THE CONDENSERS.
514 00:54:29:10 00:54:30:23 SOMETIMES ARTIFICIAL MEANS
515 00:54:30:25 00:54:34:23 ARE USED TO VAPORIZE
THE GROUND WATER.
516 00:54:34:25 00:54:38:03 THIS BRINE, AS
IT EXISTS IN THE GROUND--
517 00:54:38:05 00:54:40:04 THE PRESSURE
IN THE RESERVOIR
518 00:54:40:06 00:54:43:18 IS NOT ENOUGH FOR THE BRINE
TO FLOW TO THE SURFACE.
519 00:54:43:20 00:54:45:27 SO AFTER WE DRILL A WELL,
520 00:54:45:29 00:54:48:14 WE'LL INDUCE TO FLOW
WITH NITROGEN GAS,
521 00:54:48:16 00:54:51:14 WHICH WILL START IT
TO BOILING, TO FLASHING.
522 00:54:51:16 00:54:53:21 IT'LL GENERATE
MUCH LIKE A TEAPOT.
523 00:54:53:23 00:54:55:04 IT'LL START TO BOIL.
524 00:54:55:06 00:54:58:18 IF YOU GET ENOUGH HEAT,
IT'LL BOIL OUT THE TOP.
525 00:54:58:20 00:55:01:17 WELL, THESE WELLS WILL
GENERATE THEIR OWN STEAM,
526 00:55:01:19 00:55:04:21 AND THEY WILL PRODUCE

TO THE SURFACE.
 527 00:55:06:09 00:55:09:06 *GEOHERMAL ENERGY IS
 A STABLE SOURCE OF POWER,*
 528 00:55:09:08 00:55:12:20 *WITH RELATIVELY LOW
 ENVIRONMENTAL IMPACT.*
 529 00:55:12:22 00:55:14:15 *ENVIRONMENTALLY,*
 530 00:55:14:17 00:55:18:15 *GEOHERMAL IS ONE
 OF THE MOST BENIGN ENERGY
 SOURCES WE HAVE.*
 531 00:55:18:17 00:55:21:15 *THE ONLY TWO THAT
 MIGHT BE BETTER*
 532 00:55:21:17 00:55:24:24 *WOULD BE WIND POWER
 AND PHOTOVOLTAIC CELLS.*
 533 00:55:24:26 00:55:26:25 *THE MAJOR SHORTCOMINGS
 TO GEOHERMAL*
 534 00:55:26:27 00:55:29:25 *IS IT HAS
 A HIGH CAPITAL INVESTMENT,*
 535 00:55:29:27 00:55:31:22 *SO YOU HAVE GOT TO HAVE*
 536 00:55:31:24 00:55:34:21 *A LOT OF CAPITAL
 TO GET STARTED.*
 537 00:55:34:23 00:55:36:13 *THAT'S A MAJOR DRAWBACK.*
 538 00:55:36:15 00:55:39:12 *THE SECOND DRAWBACK IS
 THAT WE'RE REALLY LIMITED.*
 539 00:55:39:14 00:55:42:26 *THERE ARE ONLY FINITE AREAS
 THAT CAN BE DEVELOPED.*
 540 00:55:42:28 00:55:45:26 *ONLY A FEW PLACES HAVE
 THE PROPER COMBINATION*
 541 00:55:45:28 00:55:49:18 *OF HEAT,
 GEOLOGIC STRUCTURE,
 AND CLEAN GROUND WATER*
 542 00:55:49:20 00:55:53:18 *TO PRODUCE
 GEOHERMAL ENERGY,*
 543 00:55:53:20 00:55:57:05 *AND SINCE HEAT IS REPLACED
 QUITE SLOWLY IN ROCKS,*
 544 00:55:57:07 00:56:00:04 *GEOHERMAL STATIONS
 USUALLY TAP ALL USEFUL ENERGY*
 545 00:56:00:06 00:56:03:15 *WITHIN JUST A FEW DECADES.*
 546 00:56:05:21 00:56:07:19 *INDIVIDUALLY,
 NEITHER GEOHERMAL,*
 547 00:56:07:21 00:56:10:19 *HYDRO, WIND,
 NOR SOLAR POWER*
 548 00:56:10:21 00:56:14:08 *CAN SUBSTITUTE FOR
 THE WORLD'S SUPPLY
 OF FOSSIL FUELS,*
 549 00:56:17:03 00:56:18:13 *BUT COLLECTIVELY,*
 550 00:56:18:15 00:56:20:19 *THEY CAN MAKE
 A SIGNIFICANT CONTRIBUTION*
 551 00:56:20:21 00:56:23:01 *TO OUR ENERGY REQUIREMENTS.*
 552 00:56:25:07 00:56:27:05 *AND AS
 THE ENVIRONMENTAL COSTS*
 553 00:56:27:07 00:56:29:21 *OF BURNING FOSSIL FUELS
 ESCALATE,*
 554 00:56:29:23 00:56:31:14 *AND RESERVES DWINDLE,*
 555 00:56:31:16 00:56:33:04 *THE NEED
 TO CONTINUE DEVELOPING*
 556 00:56:33:06 00:56:37:02 *NEW SOURCES OF ENERGY*

BECOMES EVEN GREATER.

557 00:56:40:04 00:56:42:17 AS WE APPROACH
THE 21st CENTURY,

558 00:56:42:19 00:56:45:01 THE FACT THAT
EARTH'S GEOLOGIC RESOURCES

559 00:56:45:03 00:56:46:17 ARE IN FINITE SUPPLY

560 00:56:46:19 00:56:49:18 IS A REALITY
THAT AFFECTS US ALL.

561 00:56:49:20 00:56:52:17 THERE ARE VERY REAL
AND VERY PREDICTABLE LIMITS

562 00:56:52:19 00:56:55:01 TO THE RESOURCES
AVAILABLE FOR OUR USE,

563 00:56:55:03 00:56:57:16 AND THE PRIMARY REASON
FOR THESE LIMITS

564 00:56:57:18 00:56:59:16 IS NOT SUPPLY.
IT'S DEMAND.

565 00:56:59:18 00:57:01:18 IT TOOK FOUR MILLION YEARS

566 00:57:01:20 00:57:04:18 FOR EARTH'S POPULATION
TO REACH TWO BILLION.

567 00:57:04:20 00:57:07:25 THE THIRD BILLION WAS ADDED
IN JUST THIRTY YEARS.

568 00:57:07:27 00:57:11:08 TODAY WE ARE GROWING AT
ALMOST 100 MILLION PEOPLE

569 00:57:11:10 00:57:12:24 EVERY SINGLE YEAR.

570 00:57:12:26 00:57:15:24 WITH A POPULATION AND
A DEMAND FOR RESOURCES

571 00:57:15:26 00:57:17:04 BOTH EXPLODING,

572 00:57:17:06 00:57:19:18 WE AS INDIVIDUALS
CAN NO LONGER CONTINUE

573 00:57:19:20 00:57:22:09 ALONG A PATH
OF ENERGY ADDICTION
AND WASTEFULNESS.

574 00:57:22:11 00:57:25:17 NO LONGER CAN NATIONS AFFORD
TO TAKE FROM THE LAND

575 00:57:25:19 00:57:28:02 WHILE IGNORING THE CONSEQUENCES
TO NEIGHBORING NATIONS

576 00:57:28:04 00:57:30:17 AND TO THE OTHER FORMS
OF LIFE

577 00:57:30:19 00:57:33:04 WITH WHICH
WE SHARE THIS PLANET,

578 00:57:33:06 00:57:36:04 AND NO LONGER CAN
THE WORLD COMMUNITY

579 00:57:36:06 00:57:38:02 AFFORD TO ONLY VIEW EARTH

580 00:57:38:04 00:57:41:01 THROUGH THE MYOPIC EYES
OF COMPETING SELF-INTEREST.

581 00:57:41:03 00:57:43:16 WE NEED TO ADOPT
A GLOBAL VIEW,

582 00:57:43:18 00:57:47:15 BOTH IN OUR TECHNOLOGY
AND OUR PHILOSOPHY.

583 00:58:02:28 00:58:05:25 CAPTIONING PERFORMED BY
THE NATIONAL CAPTIONING
INSTITUTE, INC.

584 00:58:05:27 00:58:08:24 CAPTIONS COPYRIGHT 1992
THE CORPORATION FOR COMMUNITY
COLLEGE TELEVISION

585 00:59:09:00 00:59:12:11 Annenberg Media

586	00:59:12:13	00:59:17:17	§
587	00:59:17:19	00:59:19:03	For information
		about this	
588	00:59:19:05	00:59:21:21	and other Annenberg
		Media programs	
589	00:59:21:23	00:59:24:07	call 1-800-LEARNER
		and visit us at	
590	00:59:24:09	00:59:28:22	www.learner.org .