1 00:33:12:25 00:33:16:07 Annenberg Media
2 00:33:16:09 00:34:03:25 §
3 00:34:03:27 00:34:05:13 AT FIRST GLANCE,
4 00:34:05:15 00:34:08:07 THERE'S NOTHING PARTICULARLY REMARKABLE ABOUT THIS SCENE.
5 00:34:08:09 00:34:10:20 THIS ARE OBJECTS YOU MIGHT FIND
6 00:34:10:22 00:34:12:06 AT ANY TYPICAL CAMPSITE.
7 00:34:12:08 00:34:14:21 HOWEVER, THERE IS A CONNECTION BETWEEN THEM
8 00:34:14:23 00:34:16:20 THAT GOES BEYOND THEIR OBVIOUS FUNCTION.
9 00:34:16:22 00:34:18:07 MOST OF THESE ITEMS,
10 00:34:18:09 00:34:21:07 AS WELL AS THOSE THAT FILL OUR EVERYDAY LIVES,
11 00:34:21:09 00:34:23:21 ARE MADE, AT LEAST IN PART, OF MINERALS,
12 00:34:23:23 00:34:26:21 THE NATURAL MATERIALS OF WHICH THE EARTH IS COMPOSED.
13 00:34:26:23 00:34:28:20 GEOLOGISTS DEFINE MINERALS AS SOLID SUBSTANCES
14 00:34:28:22 00:34:31:19 THAT ARE NATURALLY-OCCURRING AND INORGANIC.
15 00:34:31:21 00:34:34:22 MINERALS ALSO HAVE A DEFINITE CHEMICAL COMPOSITION,
16 00:34:34:24 00:34:38:06 IN WHICH THE ATOMS ARE ARRANGED IN AN ORDERLY PATTERN
17 00:34:38:08 00:34:39:21 CALLED A CRYSTALLINE STRUCTURE.
18 00:34:39:23 00:34:41:20 THOUSANDS OF DIFFERENT CHEMICAL COMPOSITIONS
19 00:34:41:22 00:34:44:06 AND CRYSTALLINE STRUCTURES OCCUR IN NATURE,
20 00:34:44:08 00:34:45:20 AND COMBINATIONS OF THESE
21 00:34:45:22 00:34:48:20 RESULT IN THOUSANDS OF DIFFERENT MINERAL VARIETIES.
22 00:34:48:22 00:34:52:22 IF WERE TO TAKE AWAY THE OBJECTS FROM THIS CAMPSITE
23 00:34:52:24 00:34:55:20 THAT REQUIRE MINERALS IN THEIR MANUFACTURE,
24 00:34:55:22 00:34:58:28 THERE WOULD BE VERY LITTLE LEFT TO LOOK AT...
25 00:35:01:05 00:35:02:18 OR SIT ON.
26 00:35:07:18 00:35:10:05 HUMAN SOCIETY DEPENDS ON THE PRODUCTS
27 00:35:10:07 00:35:11:19 IT INVENTS AND MANUFACTURES,
28 00:35:11:21 00:35:14:05 AND MINERALS ARE AN IMPORTANT RAW MATERIAL.
29 00:35:14:07 00:35:16:19 THE MINERALS WE USE IN THE MANUFACTURE
30 00:35:16:21 00:35:18:03 OF CONSUMER GOODS
31 00:35:18:05 00:35:21:03 AND THAT ARE PART OF VIRTUALLY ANY MAN-MADE OBJECT,
32 00:35:21:05 00:35:22:16 ARE ALSO FOUND HERE,
33 00:35:22:18 00:35:24:15 IN THE ROCKS

OF THE EARTH'S CRUST.

34 00:35:26:05 00:35:29:05 *IN THIS OPEN-PIT MINE,*
FOR EXAMPLE,

35 00:35:29:07 00:35:33:04 *IRON ORE IS EXTRACTED*
FROM THE EARTH.

36 00:35:33:06 00:35:36:18 *IT IS SMELTED AND COMBINED*
WITH OTHER MINERAL PRODUCTS

37 00:35:36:20 00:35:38:04 *TO FORM STEEL,*

38 00:35:38:06 00:35:40:19 *WHICH IS MOLDED*
TO MAKE AUTOMOBILES,

39 00:35:40:21 00:35:42:03 *SHIPS, AND SKYSCRAPERS.*

40 00:35:46:06 00:35:50:03 *FROM THESE SAND DUNES,*
QUARTZ GRAINS ARE SEPARATED...

41 00:35:53:20 00:35:56:21 *THEN MELTED AND MOLDED*
TO FORM GLASS...

42 00:35:59:02 00:36:03:04 *WHICH IS USED TO FILL*
THE WINDOWS OF THE WORLD.

43 00:36:04:21 00:36:08:11 *ROCKS ARE SIMPLY AGGREGATES*
OF MINERAL GRAINS.

44 00:36:08:13 00:36:10:09 *THE ROCK GRANITE,*
FOR EXAMPLE,

45 00:36:10:11 00:36:13:17 *IS MOSTLY MADE UP*
OF PLAGIOCLASE, QUARTZ,

46 00:36:13:19 00:36:15:01 *AND ORTHOCLASE...*

47 00:36:17:24 00:36:21:20 *WHILE BASALT TYPICALLY CONTAINS*
OLIVINE AND PLAGIOCLASE.

48 00:36:24:19 00:36:27:02 *AND SO, APART FROM*
THEIR VALUE

49 00:36:27:04 00:36:29:01 *AS COMPONENTS*
OF EVERYDAY OBJECTS,

50 00:36:29:03 00:36:33:18 *MINERALS ARE ALSO USEFUL TOOLS*
FOR CLASSIFYING ROCKS.

51 00:36:33:20 00:36:36:18 *THE MINERALS CONTAINED IN ROCKS*
PROVIDE HIDDEN CLUES

52 00:36:36:20 00:36:39:21 *ABOUT THE CONDITIONS*
UNDER WHICH THE ROCKS FORMED.

53 00:36:47:19 00:36:50:03 A MINERAL IS LIKE
A LITTLE FOSSIL.

54 00:36:50:05 00:36:52:29 IT'S AN HISTORIAN
OF A PAST TIME.

55 00:36:53:01 00:36:55:17 FOSSILS TELL US ABOUT
PAST LIVING CONDITIONS

56 00:36:55:19 00:36:58:02 OF WHERE THAT FOSSIL
GREW AND LIVED

57 00:36:58:04 00:36:59:17 AT A VERY
DIFFERENT AGE.

58 00:36:59:19 00:37:01:16 AND MINERALS DO
THE SAME THING.

59 00:37:01:18 00:37:03:16 MINERALS IN A GIVEN ROCK

60 00:37:03:18 00:37:06:03 ARE MILLIONS, IF NOT
BILLIONS OF YEARS OLD,

61 00:37:06:05 00:37:08:03 BUT THEY TRAP
WITHIN THEMSELVES,

62 00:37:08:05 00:37:10:14 WITHIN THEIR OWN
INTERNAL COMPOSITIONS

63 00:37:10:16 00:37:12:16 THEIR OWN HISTORY.

64 00:37:12:18 00:37:16:00 DIFFERENT GEOLOGISTS USE
MINERALS IN DIFFERENT WAYS.
65 00:37:16:02 00:37:17:14 A GEOCHRONOLOGIST
USES MINERALS
66 00:37:17:16 00:37:20:15 TO DETERMINE
THE AGE OF A ROCK,
67 00:37:20:17 00:37:23:15 WHETHER IT BE IN MILLIONS
OR BILLIONS OF YEARS,
68 00:37:23:17 00:37:25:26 USING RADIOACTIVE ELEMENTS
THAT ARE IN EACH MINERAL.
69 00:37:25:28 00:37:28:25 THE SEDIMENTARY PETROLOGIST
AND STRATIGRAPHER
70 00:37:28:27 00:37:31:00 USE MINERALS IN A SEDIMENT
71 00:37:31:02 00:37:34:09 TO DETERMINE HOW
THAT SEDIMENT WAS FORMED
72 00:37:34:11 00:37:36:00 INTO A SEDIMENTARY ROCK.
73 00:37:36:02 00:37:39:00 AND SOME OF THOSE MINERALS
IN A SEDIMENT
74 00:37:39:02 00:37:42:01 TELL THAT GEOLOGIST ABOUT
MOUNTAINS THAT WERE ONCE THERE,
75 00:37:42:03 00:37:45:19 ERODED TO FORM
A SEDIMENTARY ROCK.
76 00:37:45:21 00:37:48:19 THE IGNEOUS PETROLOGIST
AND METAMORPHIC PETROLOGIST
77 00:37:48:21 00:37:51:15 USE MINERALS TO DETERMINE
THE PRESSURE AND TEMPERATURE
78 00:37:51:17 00:37:54:00 RECORDED DURING
A ROCK'S CRYSTALLIZATION
79 00:37:54:02 00:37:55:15 FROM A MOLTEN MAGMA
80 00:37:55:17 00:37:59:01 OR DEFORMATION DURING
METAMORPHISM.
81 00:37:59:03 00:38:00:15 IN PLATE TECTONICS,
82 00:38:00:17 00:38:03:00 A STRUCTURAL GEOLOGIST
USES MINERALS AS WELL.
83 00:38:03:02 00:38:05:15 MANY MINERALS RECORD
MAGNETIC DIRECTIONS,
84 00:38:05:17 00:38:08:00 AND AS THE PLATES
HAVE MIGRATED,
85 00:38:08:02 00:38:10:06 THE MAGNETIC DIRECTIONS
ARE SHIFTED,
86 00:38:10:08 00:38:13:13 AND SO MINERALS
HAVE RECORDED PLATE MOTION.
87 00:38:13:15 00:38:15:27 SO WE HAVE
LEARNED A LOT
88 00:38:15:29 00:38:18:27 ABOUT WHERE THE PLATES WERE,
RELATIVE TO TODAY,
89 00:38:18:29 00:38:20:28 FROM THE MINERALS.
90 00:38:21:00 00:38:23:14 DIFFERENT GEOLOGISTS
HAVE LEARNED DIFFERENT THINGS,
91 00:38:23:16 00:38:26:13 BUT THE MINERALS HAVE
RECORDED THAT INFORMATION
92 00:38:26:15 00:38:29:06 DESPITE THEIR GREAT
ANTIQUITY OF AGE.
93 00:38:30:29 00:38:33:29 *OVER 2,000 VARIETIES*
OF MINERALS ON EARTH
94 00:38:34:01 00:38:35:27 *HAVE BEEN IDENTIFIED...*

95 00:38:38:26 00:38:41:27 *AND NEW ONES ARE STILL BEING DISCOVERED.*
96 00:38:44:29 00:38:46:13 *BUT MOST ARE RARE,*
97 00:38:46:15 00:38:49:12 *INCLUDING SOME THAT HAVE ONLY BEEN FOUND*
98 00:38:49:14 00:38:52:14 *AT A SINGLE LOCATION ON THE PLANET.*
99 00:38:52:16 00:38:55:13 *IN FACT, THE COMMON TYPES OF MINERALS*
100 00:38:55:15 00:38:56:28 *NUMBER ONLY ABOUT 200.*
101 00:38:58:14 00:39:00:18 *EXAMPLES INCLUDE QUARTZ...*
102 00:39:02:20 00:39:03:25 *OLIVINE...*
103 00:39:04:27 00:39:06:27 *ORTHOCLASE,*
104 00:39:06:29 00:39:08:10 *AND PLAGIOCLASE.*
105 00:39:09:29 00:39:11:27 *THESE COMMON MINERAL VARIETIES*
106 00:39:11:29 00:39:13:27 *ARE CALLED ROCK-FORMING MINERALS*
107 00:39:13:29 00:39:17:11 *BECAUSE THEY COMPRISE MOST OF THE ROCKS ON EARTH*
108 00:39:17:13 00:39:20:25 *AND ALSO SERVE AS THE BASIS FOR CLASSIFYING THEM.*
109 00:39:23:12 00:39:26:12 *OF COURSE, BEFORE A ROCK CAN BE CLASSIFIED,*
110 00:39:26:14 00:39:28:12 *ITS MINERALS MUST BE IDENTIFIED.*
111 00:39:28:14 00:39:31:11 *THIS IS ONE OF THE MOST FUNDAMENTAL TASKS*
112 00:39:31:13 00:39:32:26 *IN ALL OF GEOLOGY.*
113 00:39:38:13 00:39:40:11 *THE DIFFERENCES BETWEEN MINERAL VARIETIES*
114 00:39:40:13 00:39:42:27 *ARE RELATED TO THEIR ATOMIC STRUCTURE.*
115 00:39:42:29 00:39:45:27 *THE ATOMS THAT MAKE UP A MINERAL*
116 00:39:45:29 00:39:47:27 *ARE PERFECTLY AND SYMMETRICALLY ARRANGED*
117 00:39:47:29 00:39:50:10 *IN AN ALMOST INFINITE, THREE-DIMENSIONAL*
118 00:39:50:12 00:39:51:18 *CRYSTAL LATTICEWORK.*
119 00:39:51:20 00:39:53:10 *THIS STRUCTURE IS HELD TOGETHER*
120 00:39:53:12 00:39:55:25 *BY A VARIETY OF CHEMICAL BONDS.*
121 00:39:58:13 00:39:59:28 *INDIVIDUAL ATOMS OFTEN OCCUR*
122 00:40:00:00 00:40:03:26 *AS ELECTRICALLY-CHARGED PARTICLES CALLED IONS.*
123 00:40:03:28 00:40:06:11 *ONE IMPORTANT BOND IS FORMED*
124 00:40:06:13 00:40:09:24 *WHEN THESE IONS COMBINE TO NEUTRALIZE THEIR CHARGES.*
125 00:40:09:26 00:40:12:24 *THIS RESULTS IN THE MORE STABLE CONFIGURATION*
126 00:40:12:26 00:40:14:08 *OF A CRYSTAL STRUCTURE.*
127 00:40:19:12 00:40:20:29 *A SOMEWHAT*

ANALOGOUS SITUATION

128 00:40:21:01 00:40:25:11 *MIGHT BE THE RELATIONSHIP*
BETWEEN LOOSE CINDER BLOCKS

129 00:40:25:13 00:40:27:09 *AND A CINDER BLOCK WALL*

130 00:40:27:11 00:40:29:08 *THAT HAS BEEN*
CAREFULLY CONSTRUCTED

131 00:40:29:10 00:40:30:23 *AND MORTARED TOGETHER.*

132 00:40:32:26 00:40:35:23 *BOTH ARE COMPOSED*
OF THE SAME RAW MATERIAL,

133 00:40:35:25 00:40:38:25 *BUT THE WALL*
IS STRONG AND STABLE

134 00:40:38:27 00:40:41:24 *BECAUSE OF THE WAY*
THE INDIVIDUAL BLOCKS

135 00:40:41:26 00:40:43:09 *ARE MORTARED TOGETHER.*

136 00:40:43:11 00:40:44:23 *ON AN ATOMIC LEVEL,*

137 00:40:44:25 00:40:46:09 *EACH TYPE OF MINERAL*

138 00:40:46:11 00:40:48:24 *HAS ITS OWN UNIQUE*
CRYSTAL FRAMEWORK

139 00:40:48:26 00:40:52:04 *BASED ON AN ORDERLY*
ARRANGEMENT OF BONDED ATOMS.

140 00:40:52:06 00:40:55:25 *CRYSTAL GROWTH OCCURS*
ATOM BY ATOM,

141 00:40:55:27 00:40:57:09 *LAYER BY LAYER,*

142 00:40:57:11 00:40:59:09 *IN EXACTLY*
THE SAME PATTERN,

143 00:40:59:11 00:41:01:08 *REPEATED OVER*
AND OVER AGAIN.

144 00:41:02:25 00:41:04:08 *THIS REGULAR*
INTERNAL STRUCTURE

145 00:41:04:10 00:41:07:10 *HAS A GREAT DEAL TO DO*
WITH THE SHAPE

146 00:41:07:12 00:41:10:06 *AND PHYSICAL PROPERTIES*
OF THE RESULTING MINERAL.

147 00:41:13:09 00:41:14:23 *AS IT TURNS OUT,*

148 00:41:14:25 00:41:16:08 *A MINERAL'S*
PHYSICAL PROPERTIES

149 00:41:16:10 00:41:17:22 *ARE USUALLY*
QUITE DIFFERENT

150 00:41:17:24 00:41:20:21 *FROM THOSE OF THE ELEMENTS*
THAT COMPOSE IT.

151 00:41:23:24 00:41:26:25 *A GOOD EXAMPLE IS HALITE.*

152 00:41:26:27 00:41:28:25 *HALITE IS A MINERAL*
THAT FORMS

153 00:41:28:27 00:41:31:07 *WHEN SODIUM*
AND CHLORINE ATOMS JOIN

154 00:41:31:09 00:41:34:01 *DURING THE EVAPORATION*
OF A LAKE.

155 00:41:36:08 00:41:37:23 *BY THEMSELVES,*

156 00:41:37:25 00:41:40:13 *EACH OF THESE ELEMENTS*
IS EXTREMELY DANGEROUS,

157 00:41:40:15 00:41:42:13 *SODIUM BEING*
AN EXPLOSIVE METAL

158 00:41:42:15 00:41:45:13 *AND CHLORINE*
A POISONOUS GAS.

159 00:41:50:09 00:41:52:20 *YET WHEN THEY ARE*
JOINED TOGETHER,

160 00:41:52:22 00:41:55:04 *SODIUM AND CHLORINE*
COMBINE TO FORM SOMETHING
161 00:41:55:06 00:41:58:06 *MOST OF US*
USE ALL THE TIME--
162 00:41:58:08 00:42:01:02 *ORDINARY TABLE SALT.*
163 00:42:01:04 00:42:03:08 *ANOTHER MINERAL*
WITH PHYSICAL PROPERTIES
164 00:42:03:10 00:42:06:21 *THAT ARE DIFFERENT FROM THOSE*
OF ITS CHEMICAL COMPONENTS
165 00:42:06:23 00:42:07:26 *IS QUARTZ.*
166 00:42:09:04 00:42:11:29 AND IF YOU LOOK
AT THAT MINERAL QUARTZ,
167 00:42:12:01 00:42:13:14 IT'S COMPOSED
OF SILICON,
168 00:42:13:16 00:42:17:02 WHICH IN ITS PURE STATE
WOULD BE A WHITE POWDER,
169 00:42:17:04 00:42:18:19 AND ALSO OXYGEN,
170 00:42:18:21 00:42:21:21 WHICH IS PART OF
THE ATMOSPHERE WE BREATHE.
171 00:42:21:23 00:42:24:20 PURE OXYGEN IS SOMETHING
THAT IS VERY FLAMMABLE,
172 00:42:24:22 00:42:27:20 SOMETHING THAT WILL,
WITH THE SLIGHTEST SPARK,
173 00:42:27:22 00:42:29:05 OXYGEN WILL BURN.
174 00:42:29:07 00:42:31:20 SO YOU TAKE A GAS,
OXYGEN,
175 00:42:31:22 00:42:33:20 AND A WHITE POWDER,
SILICON,
176 00:42:33:22 00:42:35:19 AND YOU COMBINE THEM
TOGETHER,
177 00:42:35:21 00:42:38:06 AND THEY COMBINE
VERY READILY TOGETHER,
178 00:42:38:08 00:42:40:20 AND THEY FORM
A MINERAL, QUARTZ,
179 00:42:40:22 00:42:42:20 THAT IS HARDER
THAN STEEL
180 00:42:42:22 00:42:45:04 DUE TO ITS
THREE-DIMENSIONAL STRENGTH
181 00:42:45:06 00:42:47:19 OF BONDING BETWEEN
THE INDIVIDUAL ELEMENTS.
182 00:42:59:22 00:43:01:19 *WITH A FEW SIMPLE TOOLS--*
183 00:43:01:21 00:43:04:20 *A STEEL KNIFE,*
HYDROCHLORIC ACID,
184 00:43:04:22 00:43:06:05 *A ROCK HAMMER--*
185 00:43:06:07 00:43:09:06 *GEOLOGISTS IN THE FIELD*
CAN PERFORM TESTS
186 00:43:09:08 00:43:10:20 *TO IDENTIFY MINERALS.*
187 00:43:25:22 00:43:29:05 EACH MINERAL HAS A DISTINCTIVE
SET OF PHYSICAL PROPERTIES
188 00:43:29:07 00:43:30:20 BASED ON ITS OWN
UNIQUE COMBINATION
189 00:43:30:22 00:43:33:20 OF CHEMICAL COMPOSITION
AND CRYSTALLINE STRUCTURE.
190 00:43:33:22 00:43:35:20 PHYSICAL PROPERTIES
INCLUDE ITS COLOR,
191 00:43:35:22 00:43:37:20 THE WAY IT

REFLECTS LIGHT,
192 00:43:37:22 00:43:40:21 THE WAY IN WHICH
THE MINERAL BREAKS,
193 00:43:40:23 00:43:42:21 AND SOME SIMPLE
CHEMICAL REACTIONS.
194 00:43:42:23 00:43:44:29 THESE HELP IDENTIFY
THE MINERAL.
195 00:43:45:01 00:43:48:19 IT'S EASY TO SEE THIS ROCK
IS MADE OF DIFFERENT MINERALS
196 00:43:48:21 00:43:51:05 BECAUSE THE CRYSTALS ARE
FOUR DIFFERENT COLORS.
197 00:43:51:07 00:43:54:05 COLOR IS A FUNDAMENTAL
PROPERTY OF MINERALS.
198 00:43:54:07 00:43:56:10 LOOK AT THIS SILVER
MINERAL, MUSCOVITE.
199 00:43:56:12 00:43:58:21 IT LOOKS LIKE
A STACK OF PAPER,
200 00:43:58:23 00:44:01:04 WITH INDIVIDUAL SHEETS
FLAKING APART QUITE EASILY.
201 00:44:01:06 00:44:04:05 THE TENDENCY OF MINERALS
TO BREAK ALONG FLAT PLANES
202 00:44:04:07 00:44:05:20 IS CALLED CLEAVAGE.
203 00:44:05:22 00:44:07:19 CLEAVAGE IS A PROPERTY
THAT'S DETERMINED
204 00:44:07:21 00:44:09:03 BY THE CRYSTALLINE
STRUCTURE.
205 00:44:09:05 00:44:11:17 THIS PINK MINERAL
IS FELDSPAR.
206 00:44:14:20 00:44:16:13 UNLIKE MUSCOVITE,
207 00:44:16:15 00:44:18:00 IT HAS CLEAVAGE,
208 00:44:18:02 00:44:21:00 BUT THERE ARE TWO
DIRECTIONS OF CLEAVAGE
209 00:44:21:02 00:44:24:00 AT ABOUT 90 DEGREES
TO ONE ANOTHER.
210 00:44:31:15 00:44:33:04 THE HARDNESS OF MINERALS
211 00:44:33:06 00:44:34:19 IS ANOTHER IDENTIFYING
CHARACTERISTIC.
212 00:44:34:21 00:44:36:04 QUARTZ IS QUITE HARD.
213 00:44:36:06 00:44:39:17 IT CAN'T EVEN BE SCRATCHED
BY THIS STEEL HAMMER.
214 00:44:41:21 00:44:44:04 CALCITE LOOKS
SIMILAR TO QUARTZ,
215 00:44:44:06 00:44:47:02 BUT IS MUCH SOFTER
AND SCRATCHES EASILY.
216 00:44:51:08 00:44:54:03 LIKE CLEAVAGE, HARDNESS
IS A PHYSICAL PROPERTY
217 00:44:54:05 00:44:56:18 THAT'S DETERMINED BY
THE CRYSTALLINE STRUCTURE
218 00:44:56:20 00:44:58:18 AND IS A GOOD WAY
OF DIFFERENTIATING
219 00:44:58:20 00:45:00:03 BETWEEN THESE TWO MINERALS.
220 00:45:00:05 00:45:02:18 ANOTHER PHYSICAL
PROPERTY OF CALCITE
221 00:45:02:20 00:45:05:18 IS THAT IT DISSOLVES
IN DILUTE ACID.
222 00:45:05:20 00:45:07:19 CALCITE IS

A CARBONATE MINERAL,

223 00:45:07:21 00:45:10:05 AND THE ACID RELEASES
THE CARBON.

224 00:45:15:25 00:45:18:16 QUARTZ IS
A SILICATE MINERAL.

225 00:45:18:18 00:45:21:01 IT DOESN'T
DISSOLVE IN ACID,

226 00:45:21:03 00:45:24:00 AND SO THERE'S NO OBVIOUS
CHEMICAL REACTION.

227 00:45:25:07 00:45:27:18 THE WAY IN WHICH
MINERALS REFLECT LIGHT

228 00:45:27:20 00:45:29:29 IS THE PHYSICAL PROPERTY
CALLED LUSTER.

229 00:45:30:01 00:45:31:15 FELDSPAR HAS
A DULL LUSTER.

230 00:45:31:17 00:45:33:16 IT DOESN'T
SHINE AT ALL.

231 00:45:33:18 00:45:35:01 COMPARE THAT
TO MUSCOVITE,

232 00:45:35:03 00:45:37:00 WHICH HAS
A GLASSY LUSTER.

233 00:45:38:13 00:45:39:21 METALLIC MINERALS,
LIKE GALENA,

234 00:45:39:23 00:45:42:16 REFLECT LIGHT LIKE
A POLISHED METAL SURFACE.

235 00:45:45:18 00:45:48:00 PYRITE ALSO HAS
A METALLIC LUSTER,

236 00:45:48:02 00:45:51:00 BUT IS A DIFFERENT COLOR
THAN GALENA.

237 00:45:54:18 00:45:57:15 ONE USEFUL WAY TO DISTINGUISH
BETWEEN SOME METALLIC MINERALS

238 00:45:57:17 00:45:59:27 IS A PHYSICAL PROPERTY
CALLED STREAK.

239 00:45:59:29 00:46:04:24 WHEN WE RUB A MINERAL
AGAINST A PORCELAIN PLATE,

240 00:46:04:26 00:46:06:09 WE POWDER THE MINERAL,

241 00:46:06:11 00:46:08:28 AND BY COMPARING THE COLOR
OF THE MINERAL

242 00:46:09:00 00:46:10:14 IN ITS POWDERED FORM

243 00:46:10:16 00:46:11:29 TO THE COARSE
CRYSTALLINE FORM,

244 00:46:12:01 00:46:14:14 WE CAN DISTINGUISH
SOME TYPES OF MINERALS.

245 00:46:14:16 00:46:16:28 HEMATITE IS REDDISH BROWN
IN ITS POWDERED FORM,

246 00:46:17:00 00:46:19:14 AND GRAY METALLIC IN ITS
COARSE CRYSTALLINE FORM.

247 00:46:19:16 00:46:21:15 COMPARE THIS
TO GALENA,

248 00:46:21:17 00:46:24:14 WHICH IS GRAY,
BOTH IN THE POWDERED FORM

249 00:46:24:16 00:46:26:14 AND THE COARSE
CRYSTALLINE FORM.

250 00:46:26:16 00:46:29:14 GEOLOGISTS IN THE FIELD
USE SIMPLE TESTS LIKE THESE

251 00:46:29:16 00:46:31:15 TO HELP IDENTIFY
MINERALS AND ROCKS,
252 00:46:31:17 00:46:34:00 BUT THIS IS ONLY
THE FIRST STEP.
253 00:46:34:02 00:46:35:14 SOME MINERALS
ARE ONLY PRESENT
254 00:46:35:16 00:46:37:15 AS MICROSCOPIC
CRYSTALS IN ROCKS,
255 00:46:37:17 00:46:39:14 OTHERS IN EXTREMELY
SMALL QUANTITIES.
256 00:46:39:16 00:46:41:29 AND SOME MINERALS
CAN'T BE IDENTIFIED
257 00:46:42:01 00:46:43:14 BY PHYSICAL
PROPERTIES ALONE.
258 00:46:43:16 00:46:45:13 PETROLOGISTS,
THE GEOLOGISTS THAT STUDY
259 00:46:45:15 00:46:49:00 THE COMPOSITION AND ORIGIN
OF DIFFERENT TYPES OF ROCKS,
260 00:46:49:02 00:46:52:14 NEED TO KNOW MUCH MORE ABOUT
A ROCK SAMPLE LIKE THIS
261 00:46:52:16 00:46:53:29 AND THE MINERALS
IT CONTAINS.
262 00:46:54:01 00:46:55:14 ONCE A SAMPLE
IS COLLECTED
263 00:46:55:16 00:46:57:14 AND IDENTIFIED
IN THE FIELD,
264 00:46:57:16 00:46:59:14 IT'S TAKEN
TO THE LABORATORY
265 00:46:59:16 00:47:02:28 FOR A MUCH MORE THOROUGH
ANALYSIS OF THE MINERALS.
266 00:47:04:17 00:47:05:29 *PETROLOGIST*
LAWFORD ANDERSON
267 00:47:06:01 00:47:08:00 *IS ANALYZING*
A PIECE OF GRANITE
268 00:47:08:02 00:47:09:13 *FROM THE WHIPPLE MOUNTAINS,*
269 00:47:09:15 00:47:11:28 *WHICH LIE ALONG*
THE COLORADO RIVER
270 00:47:12:00 00:47:13:13 *IN SOUTHEASTERN CALIFORNIA.*
271 00:47:13:15 00:47:15:12 *THE PURPOSE*
OF THE INVESTIGATION
272 00:47:15:14 00:47:18:29 *IS TO DETERMINE*
THE AGE OF THE GRANITE...
273 00:47:19:01 00:47:21:12 *AS WELL AS TO FIGURE OUT*
274 00:47:21:14 00:47:23:11 *EXACTLY WHERE*
IN THE EARTH'S CRUST
275 00:47:23:13 00:47:24:11 *IT ORIGINATED.*
276 00:47:25:17 00:47:28:12 THAT ROCK COMES BACK
TO THE LABORATORY.
277 00:47:28:14 00:47:29:27 IF WE'RE GOING TO READ
278 00:47:29:29 00:47:31:27 THAT PART
OF EARTH HISTORY,
279 00:47:31:29 00:47:34:12 WE'VE GOT TO OPEN
THAT ROCK UP
280 00:47:34:14 00:47:35:27 LIKE OPENING
UP A BOOK
281 00:47:35:29 00:47:38:12 AND START TO READ

WHAT KIND OF SECRETS
282 00:47:38:14 00:47:41:20 ARE PENT UP IN ITS MINERALOGIC
OR ELEMENTAL COMPOSITION.
283 00:47:41:22 00:47:45:12 ONE OF THE FIRST THINGS
IS WE SAW THAT ROCK,
284 00:47:45:14 00:47:47:27 AND FROM THAT SLAB OF ROCK
THAT'S REMOVED--
285 00:47:47:29 00:47:50:27 WE HAVE A PIECE
OF THE ROCK HERE--
286 00:47:50:29 00:47:52:12 AND FROM THE SLAB
287 00:47:52:14 00:47:55:26 WE BREAK IT DOWN
TO A SMALLER PIECE,
288 00:47:55:28 00:47:59:21 FROM WHICH
A VERY THIN SLICE IS MADE.
289 00:47:59:23 00:48:03:12 THAT IS A LAYER OF ROCK
THAT IS SLICED SO THIN
290 00:48:03:14 00:48:05:27 THAT WE CAN PASS
LIGHT THROUGH IT
291 00:48:05:29 00:48:07:11 IN A MICROSCOPE
292 00:48:07:13 00:48:10:16 TO SEE HOW THE DIFFERENT
MINERALS ARE ARRANGED,
293 00:48:10:18 00:48:12:09 BE THEY SEDIMENTARY,
IGNEOUS,
294 00:48:12:11 00:48:13:24 OR METAMORPHIC MINERALS.
295 00:48:13:26 00:48:16:26 THEY NATURE OF THE WAY
THEY ARE INTERGROWN,
296 00:48:16:28 00:48:18:09 THEIR COMPOSITION
297 00:48:18:11 00:48:21:11 TELLS US ABOUT THE CONDITIONS
OF THAT ROCK'S HISTORY,
298 00:48:21:13 00:48:23:11 THAT PART
OF EARTH HISTORY.
299 00:48:25:27 00:48:27:24 *IN ADDITION*
TO MICROSCOPE WORK,
300 00:48:27:26 00:48:30:10 *ANDERSON ALSO USES*
X-RAY ANALYSIS
301 00:48:30:12 00:48:31:26 *TO PROVIDE IMPORTANT*
INFORMATION
302 00:48:31:28 00:48:34:11 *ABOUT THE COMPOSITION*
OF MINERALS AND ROCKS.
303 00:48:34:13 00:48:36:11 WE HAD THAT
LOW ONE LAST WEEK.
304 00:48:36:13 00:48:37:22 HAS THAT
BEEN CORRECTED?
305 00:48:40:27 00:48:43:10 *TO PREPARE THE SAMPLE*
FOR ANALYSIS,
306 00:48:43:12 00:48:45:24 *THE ROCK IS LITERALLY*
BROKEN DOWN.
307 00:49:01:12 00:49:03:27 *THIS IS DONE BY*
FIRST CRUSHING IT
308 00:49:03:29 00:49:06:12 *INTO SMALLER*
AND SMALLER PIECES.
309 00:49:12:10 00:49:14:08 *ULTIMATELY*
THE ROCK IS PULVERIZED
310 00:49:14:10 00:49:16:18 *TO THE CONSISTENCY*
OF A POWDER.
311 00:49:18:00 00:49:20:08 *THE POWDER IS CAREFULLY*

MEASURED OUT...

312 00:49:28:11 00:49:32:08 *THEN MELTED AND PRESSED INTO THE SHAPE OF A DISK.*

313 00:49:57:24 00:50:01:09 *FINALLY, THE DISK IS SUBJECTED TO X-RAY BOMBARDMENT*

314 00:50:01:11 00:50:04:08 *THAT YIELDS THE PRECISE COMPOSITION OF THE ROCK,*

315 00:50:04:10 00:50:05:22 *ELEMENT BY ELEMENT.*

316 00:50:12:07 00:50:13:21 *ANOTHER IMPORTANT ANALYSIS*

317 00:50:13:23 00:50:15:21 *INVOLVES SHOOTING BEAMS OF ELECTRONS*

318 00:50:15:23 00:50:17:22 *AT THIN SECTIONS OF ROCK*

319 00:50:17:24 00:50:20:06 *TO DETERMINE THE INDIVIDUAL MINERAL COMPOSITIONS*

320 00:50:20:08 00:50:21:23 *WITHIN THE ROCK.*

321 00:50:21:25 00:50:24:19 *THE DATA DERIVED FROM THESE PROCEDURES IS VITAL.*

322 00:50:24:21 00:50:27:04 *IT ENABLES ANDERSON AND HIS COLLEAGUES*

323 00:50:27:06 00:50:29:19 *TO ASCERTAIN THE PRESSURE AND DEPTH*

324 00:50:29:21 00:50:31:18 *AT WHICH THE GRANITE FORMED.*

325 00:50:32:27 00:50:34:07 [ANDERSON] WHAT WE FOUND OUT

326 00:50:34:09 00:50:36:22 ABOUT THE ROCKS FROM THE WHIPPLE MOUNTAINS

327 00:50:36:24 00:50:38:00 IS THAT THEY ORIGINATED

328 00:50:38:02 00:50:40:15 FROM THE MIDDLE CRUST OF THE EARTH.

329 00:50:40:17 00:50:44:21 SOME 25 OR PERHAPS EVEN MORE THAN 3O KILOMETERS DOWN,

330 00:50:44:23 00:50:48:06 THOSE MINERALS WERE CRYSTALLIZING FROM A MAGMA

331 00:50:48:08 00:50:50:20 THAT WAS IN PLACE IN THAT LEVEL,

332 00:50:50:22 00:50:52:16 DEEP IN THE EARTH'S CRUST,

333 00:50:52:18 00:50:54:01 89 MILLION YEARS AGO.

334 00:50:54:03 00:50:56:21 SO TODAY WE'VE BROUGHT THE ROCKS BACK.

335 00:50:56:23 00:50:58:06 THEY'RE AT THE SURFACE NOW,

336 00:50:58:08 00:50:59:21 BUT THEY WERE ONCE DEEP,

337 00:50:59:23 00:51:01:20 AND THEY RECORD IN THEIR COMPOSITION

338 00:51:01:22 00:51:03:06 AND IN THEIR MINERALOGY

339 00:51:03:08 00:51:06:05 HOW THE MIDDLE CRUST ORIGINATES.

340 00:51:09:05 00:51:12:05 *THE CONDITIONS UNDER WHICH A MINERAL IS CREATED*

341 00:51:12:07 00:51:15:04 *MAY BE CLEARLY REFLECTED IN ITS ATOMIC STRUCTURE*

342 00:51:15:06 00:51:17:18 *AND THEREFORE IN*

ITS PHYSICAL PROPERTIES.

343 00:51:19:21 00:51:22:04 *DIAMONDS AND GRAPHITE*
ARE PERFECT ILLUSTRATIONS
344 00:51:22:06 00:51:23:21 *OF THE RELATIONSHIP*
345 00:51:23:23 00:51:26:05 *BETWEEN A MINERAL'S*
ENVIRONMENT OF FORMATION,
346 00:51:26:07 00:51:29:20 *CRYSTAL STRUCTURE,*
AND PHYSICAL CHARACTERISTICS.
347 00:51:29:22 00:51:31:19 *DIAMONDS HAVE*
LONG BEEN COVETED
348 00:51:31:21 00:51:35:12 *AS PERHAPS THE MOST BEAUTIFUL*
AND PRECIOUS OF ALL GEMS.
349 00:51:35:14 00:51:36:27 IS THIS RETURNABLE?
350 00:51:36:29 00:51:38:11 YES, IT IS.
351 00:51:38:13 00:51:41:11 *GRAPHITE, WHICH IS*
USED IN PENCILS,
352 00:51:41:13 00:51:44:12 *IS EXTREMELY COMMONPLACE*
AND FAR LESS VALUABLE,
353 00:51:44:14 00:51:47:27 *YET BOTH MINERALS ARE MADE*
OF THE SAME SUBSTANCE,
354 00:51:47:29 00:51:49:25 *PURE CARBON.*
355 00:51:49:27 00:51:53:04 *THE GREAT CONTRAST BETWEEN*
THEIR PHYSICAL PROPERTIES
356 00:51:53:06 00:51:54:19 *CAN BE ATTRIBUTED*
357 00:51:54:21 00:51:56:18 *TO THE DIFFERING*
STRUCTURAL ARRANGEMENTS
358 00:51:56:20 00:51:58:03 *OF THEIR CARBON ATOMS.*
359 00:51:59:10 00:52:01:13 A DIAMOND IS THE HARDEST
OF ALL MINERALS.
360 00:52:01:15 00:52:02:26 WHY IS IT SO HARD?
361 00:52:02:28 00:52:05:18 IT'S BECAUSE IT HAS
A VERY SPECIAL,
362 00:52:05:20 00:52:08:17 UNIQUE COVALENT BOND
363 00:52:08:19 00:52:12:02 THAT HOLDS THE DIFFERENT
CARBON ATOMS SO TIGHTLY
364 00:52:12:04 00:52:14:01 THAT THEY CANNOT
BE SCRATCHED.
365 00:52:14:03 00:52:15:06 IN CONTRAST,
366 00:52:15:08 00:52:17:03 GRAPHITE,
ALSO A CARBON MINERAL,
367 00:52:17:05 00:52:19:18 THE SAME CARBON ATOMS
ARE HELD
368 00:52:19:20 00:52:22:17 WITH A VERY DIFFERENT
KIND OF BOND.
369 00:52:22:19 00:52:24:17 IT'S A VERY SOFT BOND,
370 00:52:24:19 00:52:26:02 AND THE MINERAL
BECOMES SOFT,
371 00:52:26:04 00:52:29:02 AND THAT'S WHY WE CAN USE
GRAPHITE IN PENCILS.
372 00:52:29:04 00:52:31:02 SO HARDNESS
IS ONE ASPECT,
373 00:52:31:04 00:52:34:03 DIRECTLY RELATED TO THE BONDING
HOLDING THE STRUCTURE TOGETHER.
374 00:52:37:05 00:52:38:18 *THE COVALENT BOND*
375 00:52:38:20 00:52:41:02 *GIVES A STRONGLY INTERLOCKING*
ATOMIC ARRANGEMENT

376 00:52:41:04 00:52:43:16 *TO THE CARBON ATOMS*
IN DIAMOND.
377 00:52:43:18 00:52:46:17 *THE WEAK BONDS OF CARBON*
AND GRAPHITE, HOWEVER,
378 00:52:46:19 00:52:48:16 *DEVELOP A LAYERED*
CRYSTAL STRUCTURE.
379 00:52:50:29 00:52:53:27 GRAPHITE IS FORMED
UNDER LOW-PRESSURE CONDITIONS,
380 00:52:53:29 00:52:55:11 NEAR SURFACE,
381 00:52:55:13 00:52:58:23 WHILE DIAMOND IS FORMED UNDER
TREMENDOUSLY HIGH PRESSURES,
382 00:52:58:25 00:53:01:22 IN FACT, NEEDS GREAT DEPTHS
IN THE EARTH TO FORM,
383 00:53:01:24 00:53:03:28 DEPTHS THAT ARE
WELL WITHIN THE MANTLE.
384 00:53:07:20 00:53:10:03 *IT IS THESE*
DEPTHS AND PRESSURES
385 00:53:10:05 00:53:12:17 *THAT GIVE A DIAMOND*
ITS COVALENT BONDING
386 00:53:12:19 00:53:14:01 *AND DAZZLING BEAUTY*
387 00:53:14:03 00:53:16:17 *AND MAKE IT THE RARE*
AND SOUGHT AFTER JEWEL
388 00:53:16:19 00:53:18:16 *IT HAS BEEN*
THROUGHOUT HISTORY.
389 00:53:20:03 00:53:21:18 *ANOTHER RARE MINERAL*
390 00:53:21:20 00:53:23:17 *WITH A LONG*
AND ILLUSTRIOUS PAST
391 00:53:23:19 00:53:25:02 *IS GOLD.*
392 00:53:26:20 00:53:29:02 *FEW OTHER MINERALS*
HAVE EVER HAD
393 00:53:29:04 00:53:31:02 *ITS ECONOMIC*
OR POLITICAL POWER.
394 00:53:31:04 00:53:33:01 *YET UNLIKE COPPER*
AND SILVER,
395 00:53:33:03 00:53:35:02 *WHICH HAVE VARIOUS*
INDUSTRIAL USES,
396 00:53:35:04 00:53:37:16 *GOLD HAS ONLY LIMITED*
PRACTICAL VALUE.
397 00:53:40:00 00:53:43:03 *THE CONSIDERABLE VALUE*
THAT GOLD DOES POSSESS
398 00:53:43:05 00:53:45:16 *IS BASED ON ITS*
HISTORICAL FUNCTION
399 00:53:45:18 00:53:47:17 *AS A KIND OF*
UNIVERSAL CURRENCY
400 00:53:47:19 00:53:50:02 *IN A WORLD WHERE COUNTRIES*
HAVE LITTLE FAITH
401 00:53:50:04 00:53:52:01 *IN EACH OTHER'S*
PAPER MONEY.
402 00:53:54:20 00:53:57:03 *THE POWER OF GOLD*
IS EXEMPLIFIED
403 00:53:57:05 00:53:59:06 *BY THE SETTLEMENT*
OF CALIFORNIA.
404 00:53:59:08 00:54:02:01 *UNTIL THE MIDDLE*
OF THE 19th CENTURY,
405 00:54:02:03 00:54:04:00 *THIS WAS A WILD,*
UNCHARTED,

406 00:54:04:02 00:54:05:20 *SPARSELY POPULATED REGION.*
407 00:54:07:29 00:54:10:29 *THEN CAME THE DISCOVERY OF GOLD AT SUTTER'S MILL,*
408 00:54:11:01 00:54:12:15 *AND PRACTICALLY OVERNIGHT,*
409 00:54:12:17 00:54:15:10 *THOUSANDS OF PEOPLE FROM ALL WALKS OF LIFE*
410 00:54:15:12 00:54:18:05 *PULLED UP STAKES AND CONVERGED ON THE AREA,*
411 00:54:18:07 00:54:20:00 *HOPING TO STRIKE IT RICH.*
412 00:54:24:02 00:54:26:15 *THE SAME KIND OF FRENZIED ACTIVITY*
413 00:54:26:17 00:54:31:08 *WAS REPEATED AT THE END OF THE 19th CENTURY.*
414 00:54:31:10 00:54:34:00 *FOLLOWING A GOLD STRIKE IN THE KLONDIKE,*
415 00:54:34:02 00:54:35:15 *30,000 ADVENTURERS*
416 00:54:35:17 00:54:38:25 *POURED INTO WHAT IS NOW THE YUKON TERRITORY.*
417 00:54:41:29 00:54:43:29 *GOLD AND OTHER PURE MINERALS*
418 00:54:44:01 00:54:45:20 *ARE RELATIVELY UNCOMMON.*
419 00:54:45:22 00:54:47:19 *WHAT MAKES THEM SO RARE*
420 00:54:47:21 00:54:50:01 *IS THAT UNUSUAL CONDITIONS ARE REQUIRED*
421 00:54:50:03 00:54:52:26 *FOR THEM TO CONCENTRATE WITHIN THE EARTH'S CRUST.*
422 00:54:54:12 00:54:57:00 METALLIC MINERALS SUCH AS GOLD, SILVER, AND COPPER
423 00:54:57:02 00:54:59:00 ALL FORM THE SAME WAY.
424 00:54:59:02 00:55:02:01 THEY'RE PRECIPITATED FROM VERY HOT-WATER SOLUTIONS
425 00:55:02:03 00:55:03:20 CALLED HYDROTHERMAL SOLUTIONS
426 00:55:03:22 00:55:05:16 THAT PERCOLATE UP THROUGH CRACKS,
427 00:55:05:18 00:55:07:16 THROUGH FISSURES IN THE EARTH.
428 00:55:07:18 00:55:09:08 AS THEY REACH COOLER REGIONS,
429 00:55:09:10 00:55:10:23 THEY BEGIN TO CRYSTALLIZE.
430 00:55:10:25 00:55:12:13 WHATEVER METALS AND NONMETALS
431 00:55:12:15 00:55:15:28 THAT ARE DISSOLVED IN THAT HOT WATER PRECIPITATE OUT.
432 00:55:16:00 00:55:18:27 IN THE CASE OF GOLD OR SILVER OR COPPER,
433 00:55:18:29 00:55:20:27 IT CALLS FOR VERY SPECIAL WATERS.
434 00:55:20:29 00:55:22:26 THAT'S WHY THEY'RE VERY RARE.

435 00:55:25:01 00:55:26:29 *THESE WATERS*
ARE GENERALLY DERIVED
436 00:55:27:01 00:55:28:28 *DIRECTLY FROM*
CRYSTALLIZING MAGMA
437 00:55:29:00 00:55:30:28 *OR FROM HOT GROUND WATER*
438 00:55:31:00 00:55:32:13 *CIRCULATING*
THROUGH THE ROCK
439 00:55:32:15 00:55:34:18 *OVERLYING*
AN IGNEOUS INTRUSION.
440 00:55:36:15 00:55:40:03 *ANY ECONOMICALLY VIABLE*
CONCENTRATION OF MINERALS
441 00:55:40:05 00:55:42:15 *IS TERMED AN ORE DEPOSIT,*
442 00:55:42:17 00:55:44:02 *AND HYDROTHERMAL*
ORE DEPOSITS
443 00:55:44:04 00:55:47:12 *ARE AMONG THE MORE IMPORTANT*
SOURCES OF METAL KNOWN.
444 00:55:50:11 00:55:53:00 MOST OF THE ELEMENTS
THAT MAKE UP ORES
445 00:55:53:02 00:55:55:14 DON'T HAVE A HOME
IN EVERYDAY
MINERALS,
446 00:55:55:16 00:55:57:07 DON'T FIT
INTO THE STRUCTURES
447 00:55:57:09 00:55:59:06 OF QUARTZ,
FELDSPAR, OR MICA.
448 00:55:59:08 00:56:01:18 AS A LAVA
OR A MAGMA
449 00:56:01:20 00:56:04:09 BEGINS
TO CRYSTALLIZE
THE COMMON MINERALS,
450 00:56:04:11 00:56:08:09 THE ELEMENTS ARE
BUNCHED UP TOGETHER
AND CONCENTRATED,
451 00:56:08:11 00:56:11:07 BEING DISLODGED AWAY
FROM THE GROWING
CRYSTALS.
452 00:56:11:09 00:56:12:22 WATER
IS ALSO BUILDING,
453 00:56:12:24 00:56:14:21 AND AT SOME
LATE STAGE
454 00:56:14:23 00:56:17:15 IN THE
CRYSTALLIZATION OF
ALMOST ALL MAGMAS,
455 00:56:17:17 00:56:19:16 WATER BEGINS
TO BOIL OFF.
456 00:56:19:18 00:56:22:10 AS IT BOILS
AND RISES FROM
THE MAGMA SYSTEM,
457 00:56:22:12 00:56:24:11 IT TAKES
ALL THOSE ELEMENTS
458 00:56:24:13 00:56:25:29 THAT DIDN'T
HAVE HOMES.
459 00:56:26:01 00:56:28:26 THESE GO AND
FILL UP FRACTURES
THROUGH THE ROCKS
460 00:56:28:28 00:56:30:16 ABOVE

THE MAGMA CHAMBER,
461 00:56:30:18 00:56:33:14 AND AS THEY REACH
THE COOLER ROCKS,
THEY PRECIPITATE.
462 00:56:35:19 00:56:37:17 *CRYSTALLIZATION*
AND PRECIPITATION
463 00:56:37:19 00:56:39:05 *FROM A HOT SOLUTION*
464 00:56:39:07 00:56:43:01 *IS ONLY ONE OF SEVERAL WAYS*
MINERALS COMMONLY FORM.
465 00:56:46:08 00:56:47:21 *A NUMBER OF MINERALS*
466 00:56:47:23 00:56:49:16 *CRYSTALLIZE DIRECTLY*
FROM WATER.
467 00:56:49:18 00:56:51:15 *THIS OCCURS*
UNDER CERTAIN CONDITIONS
468 00:56:51:17 00:56:53:02 *THAT FAVOR*
CHEMICAL REACTIONS
469 00:56:53:04 00:56:56:01 *BETWEEN ELEMENTS ALREADY*
PRESENT IN THE WATER.
470 00:56:58:28 00:57:01:21 *A COMMON MINERAL*
THAT FORMS THIS WAY
471 00:57:01:23 00:57:06:00 *IS HEMATITE--SOMETIMES*
CALLED BLOODSTONE BY JEWELERS.
472 00:57:06:02 00:57:09:09 *HEMATITE USUALLY FORMS*
IN WELL-OXYGENATED WATER
473 00:57:09:11 00:57:11:25 *WHERE DISSOLVED IRON*
AND OXYGEN REACT
474 00:57:11:27 00:57:14:14 *AND PRECIPITATE*
AROUND SAND GRAINS,
475 00:57:14:16 00:57:16:29 *EVENTUALLY FORMING*
RED SANDSTONE.
476 00:57:19:10 00:57:21:28 *EVAPORATION OF SEA*
OR LAKE WATER
477 00:57:22:00 00:57:23:08 *TRIGGERS PRECIPITATION*
478 00:57:23:10 00:57:25:04 *OF AN IMPORTANT GROUP*
OF MINERALS
479 00:57:25:06 00:57:27:10 *CALLED EVAPORITES.*
480 00:57:27:12 00:57:30:01 *HALITE IS AN EXAMPLE.*
481 00:57:30:03 00:57:32:19 *OTHER MINERALS PRECIPITATE*
DIRECTLY FROM GASES
482 00:57:32:21 00:57:35:08 *THROUGH A PROCESS*
KNOWN AS SUBLIMATION.
483 00:57:37:26 00:57:39:25 THE SUBLIMATION PROCESS
USUALLY HAPPENS
484 00:57:39:27 00:57:42:17 WHEN YOU HAVE
A VERY HOT, VOLCANIC GAS,
485 00:57:42:19 00:57:44:17 UH, LIKE A SULFUR DIOXIDE,
486 00:57:44:19 00:57:48:08 WHICH CAN COME OUT
LITERALLY BY TONS
PER MINUTE
487 00:57:48:10 00:57:50:08 IN A LARGE
VOLCANIC ERUPTION.
488 00:57:50:10 00:57:52:21 WHEN THESE GASES
START TO COOL,
489 00:57:52:23 00:57:55:25 THEY'LL GO DIRECTLY
FROM THE GASEOUS,
VAPOR STATE

490 00:57:55:27 00:57:57:25 TO INDIVIDUAL
CRYSTALS OF SULFUR
491 00:57:57:27 00:58:02:23 AND BUILD A YELLOW MASS
AROUND THE VOLCANIC VENTS.
492 00:58:05:05 00:58:08:22 *MINERALS ALSO FORM*
BY BIOLOGIC PROCESSES,
493 00:58:08:24 00:58:11:21 *AS WHEN AN OYSTER*
MAKES A PEARL.
494 00:58:11:23 00:58:14:17 *IN ADDITION, SPONGES AND*
CORALS MAKE THEIR SHELLS
495 00:58:14:19 00:58:17:17 *OUT OF CALCIUM CARBONATE*
TAKEN FROM SEA WATER
496 00:58:17:19 00:58:20:02 *AND PRECIPITATED*
AS THE MINERALS CALCITE
497 00:58:20:04 00:58:21:16 *OR ORAGONITE.*
498 00:58:23:01 00:58:27:06 *AS WE'VE SEEN, MINERALS*
CAN FORM IN MANY WAYS.
499 00:58:27:08 00:58:29:07 *MOST ARE*
RELATIVELY UNCOMMON,
500 00:58:29:09 00:58:32:04 *WHILE A FEW DOZEN*
ARE QUITE PLENTIFUL,
501 00:58:32:06 00:58:34:23 *BUT NO MINERALS ON EARTH*
ARE MORE ABUNDANT
502 00:58:34:25 00:58:36:07 *THAN THE SILICATES.*
503 00:58:38:02 00:58:40:16 *SILICATES CONSTITUTE*
MORE THAN 90%
504 00:58:40:18 00:58:43:21 *OF ALL MINERAL VARIETIES*
ON PLANET EARTH.
505 00:58:45:24 00:58:48:17 *MOST SILICATES POSSESS*
NEITHER THE POLITICAL
506 00:58:48:19 00:58:50:16 *AND FINANCIAL*
POWER OF GOLD
507 00:58:50:18 00:58:53:15 *NOR THE EXQUISITE BEAUTY*
OF DIAMONDS.
508 00:58:55:29 00:58:59:04 *BUT THEIR ECONOMIC VALUE*
AS CONSTRUCTION MATERIAL
509 00:58:59:06 00:59:00:15 *IS ENORMOUS,*
510 00:59:00:17 00:59:02:21 *AND ONE OF THEIR*
COMMON INGREDIENTS,
511 00:59:02:23 00:59:04:08 *THE ELEMENT SILICON,*
512 00:59:04:10 00:59:05:24 *IS USED EXTENSIVELY*
513 00:59:05:26 00:59:08:19 *IN A VERY SPECIALIZED TYPE*
OF MODERN TECHNOLOGY--
514 00:59:08:21 00:59:10:09 *COMPUTERS.*
515 00:59:13:02 00:59:16:20 *PURE, SOLID SILICON*
IS CRYSTALLINE AND HARD,
516 00:59:16:22 00:59:19:04 *SO IT CAN BE SLICED*
TO A THICKNESS
517 00:59:19:06 00:59:22:09 *OF ONLY A FRACTION*
OF A CENTIMETER.
518 00:59:22:11 00:59:24:06 *IT'S ALSO A SEMICONDUCTOR,*
519 00:59:24:08 00:59:27:20 *WHICH MEANS IT CAN BE MADE*
TO CONDUCT ELECTRICITY.
520 00:59:30:07 00:59:32:04 *THESE PROPERTIES*
MAKE SILICON
521 00:59:32:06 00:59:34:05 *THE IDEAL RAW MATERIAL*

522 00:59:34:07 00:59:36:10 *FOR THE MANUFACTURE OF MICROCHIPS*
523 00:59:36:12 00:59:38:00 *USED IN COMPUTERS.*
524 00:59:43:02 00:59:44:12 *THESE DAYS,*
525 00:59:44:14 00:59:46:11 *COMPUTER TECHNOLOGY IS SO WIDESPREAD*
526 00:59:46:13 00:59:49:05 *THAT WE TEND TO TAKE IT FOR GRANTED,*
527 00:59:49:07 00:59:51:04 *BUT WITHOUT THE THIN SILICON WAFERS*
528 00:59:51:06 00:59:53:05 *MADE FROM COMMON SILICATE MINERALS,*
529 00:59:53:07 00:59:56:06 *THE AWESOME PROCESSING POWER OF THE COMPUTER AGE*
530 00:59:56:08 00:59:58:05 *MIGHT NEVER HAVE COME ABOUT.*
531 00:59:59:19 01:00:02:03 MINERALS HAVE PLAYED A FUNDAMENTAL ROLE
532 01:00:02:05 01:00:03:20 IN THE POLITICAL, ECONOMIC,
533 01:00:03:22 01:00:07:05 AND TECHNOLOGICAL EVOLUTION OF HUMAN CIVILIZATION.
534 01:00:07:07 01:00:08:18 WARS HAVE BEEN FOUGHT
535 01:00:08:20 01:00:11:19 AND EMPIRES CREATED OVER THE GEOGRAPHIC DISTRIBUTION
536 01:00:11:21 01:00:15:28 OF PRECIOUS METALS, OF GEMS, AND INDUSTRIAL MINERALS.
537 01:00:16:00 01:00:18:23 AND TODAY, MINERAL RESOURCES ARE MORE IMPORTANT
538 01:00:18:25 01:00:20:11 THAN EVER BEFORE.
539 01:00:20:13 01:00:22:28 THE PRIMARY CONCERN OF THE PETROLOGIST, HOWEVER,
540 01:00:23:00 01:00:24:17 IS PURELY SCIENTIFIC.
541 01:00:24:19 01:00:26:29 ULTIMATELY, THE LURE OF STUDYING MINERALS
542 01:00:27:01 01:00:28:18 FOR THESE GEOLOGIC DETECTIVES
543 01:00:28:20 01:00:30:28 IS TO UNRAVEL THE GEOLOGIC HISTORY,
544 01:00:31:00 01:00:32:13 NOT ONLY OF ROCKS,
545 01:00:32:15 01:00:35:04 BUT OF THE EARTH ITSELF.
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