

Planet Earth

Living Machine

- 1 01:01:46:25 CAPTIONING IS MADE POSSIBLE BY THE ANNENBERG/CPB PROJECT
- 2 01:01:51:00 THE EARTH IN SPACE, FIRST SEEN A MERE THREE DECADES AGO.
- 3 01:01:56:14 IT WAS MORE STUNNING THAN WE'D EVER IMAGINED.
- 4 01:02:00:21 WE SAW EARTH AS A PLANET AS NEVER BEFORE.
- 5 01:02:04:27 IT WAS A NEW VIEW THAT MARKED THE BEGINNING OF AN UNPRECEDENTED SEARCH TO UNDERSTAND THE DYNAMIC FORCES SHAPING OUR WORLD.
- 6 01:02:16:12 IN THE ICE FIELDS OF ANTARCTICA, SCIENTISTS HUNT FOR FRAGMENTS FROM SPACE TO FIND CLUES OF EARTH'S ORIGIN.
- 7 01:02:25:28 IN THE FIERY CAULDRON OF A HAWAIIAN VOLCANO, THEY COLLECT LIQUID ROCK THAT MAY REVEAL HIDDEN MYSTERIES OF THE EARTH'S INTERIOR.
- 8 01:02:35:27 AN OCEANOGRAPHER IN SPACE SURVEYS A GLOBAL SEA FAR MORE TURBULENT THAN EVER ENVISIONED.
- 9 01:02:43:27 DEEP-DIVING SUBMERSIBLES VENTURE INTO THE GREATEST FRONTIER ON EARTH TO DISCOVER FANTASIC NEW WORLDS IN THE ALIEN DEEP.
- 10 01:02:56:17 WE LIVE IN AN EXTRAORDINARY ERA OF EXPLORATION.
- 11 01:03:02:14 WE HAVE LEARNED THAT EARTH'S SURFACE IS CRACKED AND MOVING, THAT ITS CONTINENTS DRIFT RELENTLESSLY ACROSS THE FACE OF THE PLANET.
- 12 01:03:13:14 WE HAVE SEEN THE UNIMAGINABLE -- STRANGE PLACES WHERE THE SEA FLOOR IS PULLING APART AND WHERE NEW LAND IS BORN FROM VOLCANOES UNDER THE SEA.
- 13 01:03:27:15 WE HAVE UNLOCKED THE HISTORY OF EARTH'S CLIMATE, TO SOLVE RIDDLES OF PAST ICE AGES, TO

GLIMPSE WHAT THE FUTURE MIGHT HOLD.

- 14 01:03:39:28 OUR SPACE PROBES HAVE UNCOVERED POWERFUL ENERGY DRIVEN BY THE SUN, WHOSE IMPACT WE ARE JUST BEGINNING TO FATHOM.
- 15 01:03:52:14 WE HAVE TRAVELED TO OTHER WORLDS TO FIND SECRETS OF EARTH'S HISTORY, WONDERING IF LIFE WAS SHAPED BY COLLISIONS FROM OUTER SPACE.
- 16 01:04:05:11 OUR EARTH IS A VAST AND COMPLEX SYSTEM EVOLVED OVER BILLIONS OF YEARS, YET A NEW FORCE MAY NOW INFLUENCE ITS DESTINY.
- 17 01:04:20:26 WE STAND ON THE THRESHOLD OF A GREAT ADVENTURE, EQUIPPED WITH A NEW GENERATION OF TECHNOLOGY.
- 18 01:04:28:08 WE WILL PROBE THE EARTH AND BEYOND FOR AN EVEN MORE DRAMATIC LOOK AT OUR PLANET.
- 19 01:04:37:01 JOIN US NOW, IN THE FIRST OF A SEVEN-PART EXPLORATION, IN THE REDISCOVERY OF PLANET EARTH.
- 20 01:05:21:11 Annenberg Media
- 21 01:05:24:25 §
- 22 01:05:32:03 IBM IS PROUD TO SUPPORT THE SPIRIT OF SCIENTIFIC DISCOVERY THAT MADE THIS SERIES POSSIBLE.
- 23 01:05:43:03 FOR MOST OF MAN'S HISTORY, EARTH WAS A FRIGHTENING PLACE.
- 24 01:05:48:18 STRANGE, TORTURED LANDSCAPES INSPIRED MYTH AND LEGEND.
- 25 01:05:52:19 ON THE PACIFIC ISLAND OF HAWAII, THE VOLCANO GODDESS PELE WAS BELIEVED TO CURSE MAN BY TURNING HIM TO STONE.
- 26 01:06:01:29 PRIMITIVE PEOPLE STOOD IN AWE OF THE MAGIC FORCES SURROUNDING THEM.
- 27 01:06:14:00 A VOLCANO IS A SMALL CLUE TO THE AWESOME POWER THAT FORMS THE EARTH'S SURFACE, THAT CREATES AND DESTROYS AND CREATES AGAIN.

- 28 01:06:25:05 IN THE MID-20th CENTURY, SCIENTISTS ARRIVED AT THE MOST COMPREHENSIVE THEORY ABOUT FORCES SHAPING THE EARTH.
- 29 01:06:34:05 IT WAS CALLED PLATE TECTONICS, FROM THE DISCOVERY THAT EARTH'S RIGID OUTER SHELL IS BROKEN INTO HUGE MOVING PLATES AND FROM THE GREEK *TEKTON*, TO BUILD.
- 30 01:06:46:25 IN THIS NEW VIEW OF EARTH, THE SEEMINGLY PERMANENT MOUNTAINS, OCEANS, AND CONTINENTS ARE THE EPHEMERAL MANIFESTATIONS OF A CONTINUAL CYCLE OF CREATION AND DESTRUCTION.
- 31 01:07:02:22 AND TODAY, THE EXPLORATION CONTINUES.
- 32 01:07:07:06 I'M PETE PALMER.
- 33 01:07:09:06 LOOKS LIKE A GREAT DAY AHEAD OF US.
- 34 01:07:15:02 PETE PALMER, OF THE GEOLOGICAL SOCIETY OF AMERICA, TAKES US TO ONE OF THE WORLD'S GREAT NATURAL GEOLOGICAL LABORATORIES, WHERE MANY CHAPTERS OF EARTH HISTORY ARE REVEALED, THE GRAND CANYON.
- 35 01:07:36:22 10 MILES ACROSS, 250 MILES LONG, A MILE DEEP.
- 36 01:07:42:18 BUT MORE IMPORTANT, IT'S A STORY OF VAST CHANGES OVER VAST TIME.
- 37 01:07:48:22 THE COLORADO RIVER EXPOSED A SPECTACULAR WINDOW INTO THE PAST.
- 38 01:07:53:22 THE WALLS CONTAIN THE KINDS OF EVIDENCE THAT ESTABLISHED GEOLOGY AS A SCIENCE, EVIDENCE THAT EARTH'S HISTORY CAN BE UNDERSTOOD IF WE KNOW THE RULES.
- 39 01:08:04:24 ROCK LAYERS ARE LIKE PAGES IN A BOOK.
- 40 01:08:08:24 HORIZONTAL LAYERS PRESERVE A RECORD OF SEAS, RIVERS, AND DESERTS.
- 41 01:08:13:29 PETE PALMER DESCENDS DEEPER INTO THE TIME CAPSULE OF THE CANYON.
- 42 01:08:19:28 UNDERNEATH THOSE HORIZONTAL LAYERS, THERE'S

- A TILTED SERIES RECORDING AN OLDER RECORD OF SEAS, RIVERS, AND SOME VOLCANOES.
- 43 01:08:29:09 BENEATH THEM THERE ARE CONTORTED VERTICAL LAYERS THAT REPRESENT THE GUTS OF AN ANCIENT MOUNTAIN SYSTEM.
- 44 01:08:37:25 SCIENTISTS CAN DATE EACH OF THESE WORLDS BECAUSE RADIOACTIVE MATERIALS IN THE ROCK ACT AS A KIND OF CLOCK.
- 45 01:08:46:23 THE CANYON RECORDS SOME TWO BILLION YEARS OF AN EARTH THAT HAS CHANGED ITS SURFACE MANY TIMES.
- 46 01:08:56:24 THE GRAND CANYON DRAMATICALLY REVEALS THAT EARTH IS OLD AND EARTH IS DYNAMIC.
- 47 01:09:02:22 OVER TIME, WHOLE WORLDS HAVE BEEN CREATED AND DESTROYED AND CREATED AGAIN.
- 48 01:09:08:27 TWO CENTURIES AGO, THESE WERE RADICAL IDEAS.
- 49 01:09:12:11 THEIR ACCEPTANCE BEGAN A MAJOR REVOLUTION IN THE SCIENTIFIC UNDERSTANDING OF THE EARTH.
- 50 01:09:19:12 THE REVOLUTION BEGAN IN EDINBURGH, SCOTLAND, SOME 200 YEARS AGO.
- 51 01:09:24:20 IN THE LATE 1790s, THE INDUSTRIAL REVOLUTION AND POLITICAL REVOLUTIONS IN FRANCE AND AMERICA WERE FELT AROUND THE WORLD.
- 52 01:09:34:26 THIS SPIRIT OF CHANGE INSPIRED RADICAL NEW IDEAS IN SCIENCE.
- 53 01:09:40:16 IT WAS BELIEVED EARTH WAS CREATED BY HEAVENLY FORCES, ITS SURFACE SHAPED BY THE GREAT FLOOD IN *GENESIS* .
- 54 01:09:49:11 COUNTING LIFETIMES IN THE BIBLE, LEADING CHURCHMEN PRONOUNCED THAT EARTH WAS CREATED PRECISELY IN THE YEAR 4004 B.C.
- 55 01:09:59:12 ON OCTOBER 26th AT 9:00 IN THE MORNING.
- 56 01:10:03:11 THE EARTH WAS A MERE 6,000 YEARS OLD.

- 57 01:10:11:12 BUT 18th-CENTURY EDINBURGH, WAS A SOURCE OF INTELLECTUAL FERMENT.
- 58 01:10:17:01 AMONG THE GENIUSES OF THE NOW FAMOUS SCOTTISH ENLIGHTENMENT WAS JAMES HUTTON, THE FATHER OF GEOLOGY.
- 59 01:10:25:22 HE WOULD CHALLENGE, THEN CHANGE, THE DOGMA OF HIS DAY.
- 60 01:10:30:27 SKETCHES FOR HUTTON'S BOOK DOCUMENT HIS KEEN OBSERVATION OF NATURE.
- 61 01:10:38:25 "MIGHT THE ROCK LAYERS BE DIFFERENT WORLDS, EACH WITH ITS ORIGIN?" HUTTON SCoured THE CRAGS OF SCOTLAND IN SEARCH OF CLUES THAT WOULD TELL HOW THESE WORLDS WERE FORMED.
- 62 01:10:55:26 18th-CENTURY WISDOM DECLARED THE EARTH'S LANDSCAPE FIXED AND UNCHANGING.
- 63 01:11:00:29 BUT THE EXTINCT VOLCANOES SURROUNDING EDINBURGH AROUSED HUTTON'S SKEPTICISM.
- 64 01:11:05:28 THEY SUGGESTED TO HUTTON A DYNAMIC AND CONSTANTLY CHANGING SURFACE, DRIVEN BY WHAT HE CALLED THE EARTH'S GREAT HEAT ENGINE.
- 65 01:11:18:14 GORDON CRAIG IS THE JAMES HUTTON PROFESSOR OF GEOLOGY AT THE UNIVERSITY OF EDINBURGH.
- 66 01:11:25:13 ON EDINBURGH'S ANCIENT VOLCANO, ARTHUR'S SEAT, AND ALONG THE SALISBURY CRAGS, HE EXPLORES THE ROCKS THAT TOLD HUTTON OF A LIVING EARTH.
- 67 01:11:38:29 HUTTON HAD THIS AS HIS BACK YARD, AN OLD VOLCANO.
- 68 01:11:43:28 THE DETAILED EVIDENCE THAT ENCOURAGED HIM IN HIS THEORY OF THE EARTH WAS RIGHT HERE.
- 69 01:11:51:13 HERE YOU CAN SEE EVIDENCE OF ROCKS OVERLYING EACH OTHER.
- 70 01:11:56:12 IN THE 18th CENTURY, ALL ROCKS WERE BELIEVED LAID DOWN IN WATER.

- 71 01:12:02:16 HUTTON BELIEVED THAT THIS PARTICULAR ROCK WAS INTRUDED INTO PRE-EXISTING ROCKS.
- 72 01:12:07:19 IT WAS A MOLTEN LIQUID THAT CAME UP FROM BELOW.
- 73 01:12:13:15 BUT ANOTHER RADICAL IDEA, GEOLOGIC TIME, WAS NEEDED BEFORE EARTH COULD BE UNDERSTOOD.
- 74 01:12:19:19 HUTTON WONDERED, "HOW LONG MUST IT TAKE TO WEAR DOWN A WHOLE MOUNTAIN?" BUILT IN 200 A.D. BY THE ROMAN ARMY, HADRIAN'S WALL STRETCHES FROM SEA TO SEA ACROSS NORTHERN ENGLAND.
- 75 01:12:35:16 EROSION RELENTLESSLY DESTROYS THE LANDSCAPE, BUT HADRIAN'S WALL HADN'T CHANGED MUCH IN 16 CENTURIES.
- 76 01:12:43:00 HUTTON RECOGNIZED THAT MOUNTAINS MUST TAKE MILLIONS OF YEARS TO WEAR DOWN, NOT CENTURIES, THAT EARTH MUST BE FAR OLDER THAN 6,000 YEARS.
- 77 01:12:54:10 RADIOACTIVE DATING NOW SUGGESTS 4.6 BILLION YEARS OLD, A MILLION TIMES OLDER THAN THOUGHT IN HUTTON'S DAY.
- 78 01:13:02:16 WHEN A MOUNTAIN WEARS DOWN AND WASHES TO THE SEA, IT FORMS FLAT LAYERS OF SAND AND MUD.
- 79 01:13:12:23 HERE AT SICCAR POINT, HUTTON FOUND HORIZONTAL ROCK LAYERS, BUT BENEATH THESE WERE OTHERS, TILTED ON THEIR SIDES.
- 80 01:13:21:03 WHAT FORCE COULD BEND SOLID ROCK?
- 81 01:13:24:02 GORDON CRAIG EXPLAINS.
- 82 01:13:26:03 THIS MUST HAVE BEEN AN EXCITING LOCALITY.
- 83 01:13:29:17 THIS WAS PROBABLY HUTTON'S LAST GEOLOGICAL EXCURSION, AND HE CAME ACROSS THE ESSENCE OF HIS WHOLE THEORY OF THE EARTH.
- 84 01:13:39:18 HE REALIZED THERE WERE VERTICAL ROCKS HERE WHICH HAD ONCE BEEN HORIZONTAL SANDS AND MUDS.

- 85 01:13:47:07 THEY HAD BEEN FOLDED BY IMMEASURABLY STRONG FORCES, AND ON TOP, YOUNGER SEDIMENTS HAD BEEN LAID DOWN.
- 86 01:13:55:22 THIS CYCLICITY OF OLD LANDS WEARING AWAY AND NEW LANDS BEING FORMED WAS THE ESSENCE OF HIS THEORY OF THE EARTH.
- 87 01:14:05:24 BY ASKING HOW THESE VERTICAL ROCK LAYERS WERE FORMED, HUTTON MADE ONE OF THE GREAT LEAPS IN MANKIND'S INTELLECTUAL HISTORY.
- 88 01:14:15:19 THE ROCKS TOLD A STORY OF AN ANCIENT, DYNAMIC EARTH, "WITH NO VESTIGE OF A BEGINNING, NO PROSPECT OF AN END." THE THEOLOGIAN'S 6,000 YEARS BECAME A SINGLE TICK OF THE GEOLOGIST'S CLOCK.
- 89 01:14:32:10 OUR VIEW OF EARTH WOULD NEVER BE THE SAME.
- 90 01:14:38:24 IN THE CENTURY THAT FOLLOWED, SCIENTISTS WOULD EXPLORE FURTHER THAN EVER BEFORE.
- 91 01:14:46:25 GERMAN SCIENTIST ALFRED WEGENER WAS AT THE VANGUARD.
- 92 01:14:52:24 RARE FOOTAGE OF HIS 1930 EXPEDITION TO THE HEART OF GREENLAND SHOWS A TIME WHEN MUCH WAS TO BE LEARNED IN THE FAR REACHES OF THE EARTH.
- 93 01:15:05:21 SCIENCE HERE WAS A STRUGGLE AGAINST THE DEADLY POWERS OF NATURE.
- 94 01:15:15:10 THESE RIGOROUS EXPEDITIONS WOULD ENLARGE WEGENER'S CURIOSITY ABOUT THE EARTH.
- 95 01:15:22:06 WEGENER CONDUCTED MANY METEOROLOGICAL EXPERIMENTS, BUT HE WAS CURIOUS ABOUT MORE THAN WEATHER.
- 96 01:15:30:11 HE WAS PUZZLED BY GLACIAL DEPOSITS IN THE TROPICS, IDENTICAL FOSSILS ON SEPARATE CONTINENTS, MOUNTAIN RANGES WITH THE EXACT SAME GEOLOGY BUT SEPARATED BY VAST OCEANS.
- 97 01:15:44:06 HIS CURIOSITY DROVE HIM TO SEEK AN IMAGINATIVE SOLUTION TO THESE SCIENTIFIC PUZZLES.

- 98 01:15:53:21 LIKE GREENLAND'S SEA ICE, PERHAPS CONTINENTS COULD ALSO SPLIT AND MOVE APART.
- 99 01:16:04:18 WEGENER'S BOLD LEAP WAS TO RECONSTRUCT A WORLD WHERE THE CONTINENTS FIT TOGETHER.
- 100 01:16:11:07 HIS SKETCHES CONNECTED BROKEN MOUNTAIN CHAINS AND SOLVED OTHER UNANSWERED PROBLEMS.
- 101 01:16:16:23 THIS SINGLE GIANT CONTINENT IS CALLED PANGAEA, "ALL LANDS." THOUGH BASED ON CAREFUL SCIENTIFIC REASONING, WEGENER'S IDEAS WERE DISMISSED AS FANTASY BY SCIENTISTS OF HIS DAY.
- 102 01:16:30:22 NO FORCE COULD POSSIBLY PLOW WHOLE CONTINENTS THROUGH THE BEDROCK OF THE OCEAN BOTTOM.
- 103 01:16:36:23 WEGENER DIED IN GREENLAND, LOST IN THE FAR REACHES OF FROZEN WILDERNESS, BUT HIS VISION OF MOVING CONTINENTS WOULD HAUNT THE SCIENTIFIC WORLD UNTIL NEW DISCOVERIES AT THE BOTTOM OF THE SEA REVIVED HIS CHALLENGING IDEAS.
- 104 01:16:55:24 IN MID-CENTURY, GLOBAL RESEARCH, HIGHLIGHTED BY THE INTERNATIONAL GEOPHYSICAL YEAR OF 1957-58, PROVIDED NEW WAYS OF VIEWING THE EARTH AS A PLANET.
- 105 01:17:08:20 SPURRED BY THIS GLOBAL VIEW, SCIENTISTS EXPLORED THE OCEAN FLOOR AND COLLECTED DATA LEADING TO THE DISCOVERY OF AN EARTH MORE DYNAMIC THAN EVER ENVISIONED.
- 106 01:17:21:05 IN THE MID-ATLANTIC, SCIENTISTS DISCOVERED A MOUNTAIN RANGE THAT MIRRORED THE COASTLINES WITH SUMMITS REACHING 10,000 FEET ABOVE THE OCEAN FLOOR.
- 107 01:17:32:09 THE MOUNTAINS WIND 46,000 MILES AROUND THE GLOBE.
- 108 01:17:36:09 SPLIT BY A CENTRAL RIFT VALLEY AND ROCKED BY COUNTLESS EARTHQUAKES, NO SCIENTIFIC THEORY COULD ACCOUNT FOR THESE CURIOUS PHENOMENA.

- 109 01:17:46:25 SCIENTISTS HAD THOUGHT THE OCEAN FLOOR WAS THE EARTH'S ORIGINAL CRUST FROZEN IN TIME WHEN THE PLANET COOLED FROM A MOLTEN BALL.
- 110 01:17:57:15 BUT DREDGING BROUGHT UP RELATIVELY YOUNG ROCKS AND NEWLY CREATED VOLCANIC LAVA.
- 111 01:18:04:27 NO ROCKS WERE OLDER THAN 150 MILLION YEARS.
- 112 01:18:11:27 SEDIMENT CORERS WERE PLUNGED TO THE OCEAN BOTTOM.
- 113 01:18:16:07 SCIENTISTS EXPECTED THE CORERS TO READ LIKE AN ENCYCLOPEDIA OF THE PAST, BUT BILLIONS OF YEARS WERE MISSING.
- 114 01:18:24:17 SOME 95% OF EARTH HISTORY WAS GONE.
- 115 01:18:28:16 WHERE DID THAT HISTORY GO?
- 116 01:18:31:05 WHY WAS THE OCEAN FLOOR SO VERY YOUNG?
- 117 01:18:34:21 IN 1960, PRINCETON PROFESSOR HARRY HESS PROPOSED AN IDEA CALLED SEA FLOOR SPREADING.
- 118 01:18:41:11 HE SUPPOSED THAT MOLTEN ROCK RISING IN THE DEEP VALLEYS OF UNDERSEA MOUNTAINS FORMED NEW SEA FLOOR, SPREADING TO EACH SIDE AS NEW ROCK CAME FROM BELOW.
- 119 01:18:54:27 AN ENTIRE OCEAN FLOOR COULD BE CREATED IN ABOUT 200 MILLION YEARS.
- 120 01:19:01:00 BUT LACKING HARD EVIDENCE, HESS CALLED HIS IDEA GEOPOETRY.
- 121 01:19:05:09 IRONICALLY, SUPPORTING EVIDENCE FOR SEA FLOOR SPREADING WOULD BE FOUND ON LAND, AT THE SITE OF AN ANCIENT VOLCANIC ERUPTION.
- 122 01:19:15:13 IN OWENS VALLEY, CALIFORNIA, SCIENTISTS WOULD PROVIDE A WAY TO MEASURE THE GROWTH OF THE OCEAN FLOORS.
- 123 01:19:26:28 WHEN LAVA COOLS, IT FREEZES IN THE DIRECTION OF MAGNETIC NORTH, BUT IN SEVERAL LOCATIONS WORLDWIDE, FROZEN COMPASSES WERE DISCOVERED THAT POINTED SOUTH.

- 124 01:19:38:24 WHAT DID IT MEAN?
- 125 01:19:40:28 DO ROCKS SOMEHOW REVERSE THEIR MAGNETISM?
- 126 01:19:44:19 OR CAN THE EARTH'S MAGNETIC FIELD CHANGE DIRECTION?
- 127 01:19:55:29 SINCE 1956, ALLAN COX OF STANFORD UNIVERSITY AND BRENT DALRYMPLE OF THE U.S. GEOLOGICAL SURVEY HAVE EXPLORED THIS MAGNETIC REVERSAL MYSTERY.
- 128 01:20:07:00 WE WANTED TO COLLECT ROCK SAMPLES, LOOK AT THEIR MINERAL CONTENT, THE DIRECTION THEY WERE MAGNETIZED, AND THEIR AGES.
- 129 01:20:16:13 IF ROCKS WERE MAGNETIZED TO THE SOUTH BECAUSE THEY CONTAINED PECULIAR MINERALS, THEN ALL ROCKS MAGNETIZED TO THE SOUTH CONTAIN THOSE PECULIAR MINERALS.
- 130 01:20:27:29 IF THE MAGNETIC FIELD HAD FLIPPED, ALL ROCKS WOULD RECORD THIS FLIP AT THE SAME TIME.
- 131 01:20:36:00 FOR ACCURATE TESTING, THE SCIENTISTS MUST FIND LAVA UNDISTURBED SINCE THE ERUPTION.
- 132 01:20:42:05 THE REVERSAL HYPOTHESIS WAS EXCITING BECAUSE IT INVOLVED THE ENTIRE EARTH.
- 133 01:20:47:19 IT WAS A GLOBAL PHENOMENON.
- 134 01:20:50:04 SOMEHOW I THOUGHT IT WAS MARVELOUS THAT THE EARTH'S MAGNETIC FIELD MIGHT HAVE REVERSED ITSELF.
- 135 01:20:57:19 IT WAS JUST A HUNCH.
- 136 01:21:00:16 A DIAMOND DRILL OBTAINS LAVA CORES.
- 137 01:21:03:21 BACK IN THE LABORATORY, THEY ARE DATED AND CAREFULLY MEASURED TO DETERMINE WHETHER THEY ARE MAGNETIZED TO THE NORTH OR SOUTH.
- 138 01:21:14:06 COX TAKES A CAREFUL NOTE OF ITS ORIENTATION BY USING A COMPASS TO SIGHT ON A KNOWN LANDMARK IN THE NEARBY SIERRA NEVADA MOUNTAINS.

- 139 01:21:26:02 SUCH PRECISION IS NECESSARY TO LATER ACCURATELY DETERMINE THE LAVA'S MAGNETIC DIRECTION.
- 140 01:21:32:01 Y-AXIS IS 281.
- 141 01:21:36:12 THE FROZEN LAVA COMPASSES HERE AT BIG PINE, CALIFORNIA, REVEAL THAT THE EARTH'S MAGNETIC FIELD DID ACTUALLY FLIP TO THE SOUTH ALMOST A MILLION YEARS AGO.
- 142 01:21:49:22 WHAT CAUSES REVERSAL OF THE MAGNETIC FIELD IN THE EARTH'S FLUID DYNAMIC CORE IS YET ANOTHER MYSTERY.
- 143 01:22:04:03 THE SCIENTISTS FROM CALIFORNIA AND THEIR COLLEAGUES WOULD DRILL AND DATE HUNDREDS OF SAMPLES FROM AROUND THE GLOBE.
- 144 01:22:13:25 THEY WOULD FIND THAT ROCKS EVERYWHERE OF THE SAME AGE SIMULTANEOUSLY RECORD THE SAME MAGNETIC ORIENTATION.
- 145 01:22:24:08 THIS LED TO THE CONSTRUCTION OF A TIME SCALE OF MAGNETIC REVERSALS THAT PLOTTED THESE FLIPS.
- 146 01:22:32:07 BY 1966, COX'S GROUP WOULD CONFIRM NINE NORTH-SOUTH FLIPS IN SOME FOUR MILLION YEARS.
- 147 01:22:48:03 THE DISCOVERY WAS LIKE FINDING THE ROSETTA STONE.
- 148 01:22:52:03 BY CRACKING ITS HIEROGLYPHIC CODE, ARCHAEOLOGISTS UNLOCKED THOUSANDS OF YEARS OF EGYPTIAN HISTORY AND CULTURE.
- 149 01:23:03:05 BUT THE GEOLOGISTS WHO HELPED SOLVE THE MYSTERY OF MAGNETIC REVERSALS WEREN'T AWARE THAT THEIR REVERSAL CODE WOULD ALSO UNLOCK A RICH AND DYNAMIC EARTH HISTORY.
- 150 01:23:23:05 FOR A DECADE, RESEARCH VESSELS HAD TOWED MAGNETOMETERS ACROSS THE OCEANS.
- 151 01:23:28:16 HERE, OVER THE MID-ATLANTIC RIDGE, THE READINGS REVEALED MYSTERIOUS MAGNETIC PATTERNS, BUT NO ONE KNEW WHAT THEY MEANT.

- 152 01:23:40:11 THE KEY TO DECIPHERING THEM CAME FROM ANOTHER TEAM OF SCIENTISTS AT ENGLAND'S HISTORIC CAMBRIDGE UNIVERSITY.
- 153 01:23:48:21 PEOPLE OFTEN ASSUME THAT WE HAD THE IDEA IN THE BATH OR WHILE SHAVING.
- 154 01:23:55:20 FREDERICK VINE, A YOUNG STUDENT, WOULD TEAM WITH DRUMMOND MATTHEWS TO ANALYZE A DETAILED MAGNETIC SURVEY MATTHEWS MADE.
- 155 01:24:04:17 MADE IN '62?
- 156 01:24:06:08 WHICH I BROUGHT BACK IN '62.
- 157 01:24:09:08 BASICALLY, I HAD THE JOB OF INTERPRETING THAT.
- 158 01:24:13:22 MOST THOUGHT THE PATTERN WAS DUE TO MAGNETIC AND NONMAGNETIC BANDS OF ROCK ON THE SEA FLOOR, BUT VINE AND MATTHEWS REACHED THEIR OWN CONCLUSION.
- 159 01:24:25:17 COULD THE PATTERN BE A RECORD FROZEN INTO NEW OCEAN CRUST WHEN THE EARTH'S MAGNETIC FIELD WAS POINTING ALTERNATELY TO THE SOUTH, THEN TO THE NORTH?
- 160 01:24:38:02 AT MID-OCEAN RIDGES, HOT ROCK SURGES UPWARD, COOLS, AND IS SLOWLY CARRIED AWAY.
- 161 01:24:45:07 VINE AND MATTHEWS THEORIZED THAT NEWLY CREATED SEA FLOOR RECORDS THE DIRECTION OF THE PREVAILING MAGNETIC FIELD AND LEAVES A MATCHING PATTERN ON EACH SIDE OF THE RIDGE.
- 162 01:24:59:07 THE REMARKABLE MATCH OF THE MAGNETIC PATTERNS ON THE SEA FLOOR WITH THE MAGNETIC TIME SCALE DEVELOPED ON LAND ESTABLISHED THE CONCEPT OF SEA FLOOR SPREADING.
- 163 01:25:12:10 IF COX AND DALRYMPLE DISCOVERED THE GEOLOGIC ROSETTA STONE, VINE AND MATTHEWS LEARNED HOW TO READ IT.
- 164 01:25:25:19 1968, A SPECIALLY EQUIPPED RESEARCH VESSEL, THE *GLOMAR CHALLENGER*, IS DISPATCHED TO THE SOUTH ATLANTIC.

- 165 01:25:33:24 IT DRILLS SAMPLE CORES ALONG THE MID-ATLANTIC RIDGE.
- 166 01:25:37:20 ROCK AND MARINE FOSSILS BROUGHT TO THE SURFACE SHOW THAT THE SEA FLOOR GROWS PROGRESSIVELY OLDER THE FARTHER IT IS FROM THE RIDGE.
- 167 01:25:51:00 *GLOMAR'S* DRILLING PROVIDED THE FIRST CONFIRMATION OF SEA FLOOR SPREADING, NEARLY AN INCH A YEAR.
- 168 01:25:58:29 GEOPOETRY HAD SEEMINGLY BECOME GEOFACT.
- 169 01:26:06:07 400 MILES SOUTHWEST OF THE AZORES, SCIENTISTS PREPARE FOR EXTRAORDINARY ADVENTURE.
- 170 01:26:14:13 ***WARNING FORMAT ERROR WITH AMERICA'S *ALVIN*, WILL GIVE SCIENTISTS A FIRSTHAND LOOK AT SEA FLOOR SPREADING.
- 171 01:26:23:20 DUBBED "PROJECT FAMOUS," THE EXPEDITION INTO THE DEEP BEGAN FOUR YEARS AFTER MAN LANDED ON THE MOON.
- 172 01:26:32:18 *ALVIN* SINKS FOR TWO MILES INTO A VALLEY THE SIZE OF THE GRAND CANYON.
- 173 01:26:42:01 THE SCIENTISTS FILM SEA FLOOR CRACKS, EVIDENCE THAT THE PLATES ARE PULLING APART.
- 174 01:26:54:10 DISTINCTIVE FORMATIONS CALLED PILLOWS DEMONSTRATE VOLCANIC ERUPTIONS BELOW CREATE NEW SEA FLOOR SIMILAR TO THIS PILLOW LAVA FORMING OFF THE COAST OF HAWAII.
- 175 01:27:07:13 THE FIRES OF CREATION BURN UNDER THE SEA.
- 176 01:27:16:12 AS THIS NEW LAVA AND THE ROCKS BENEATH IT COOL, THEY THICKEN TO SOME 60 MILES, FORMING THE OUTER SHELL OF THE GLOBE, CALLED THE LITHOSPHERE.
- 177 01:27:29:12 NUMEROUS SHALLOW EARTHQUAKES ARE RECORDED ALONG THESE MID-OCEAN RIDGES, STILL DEEPER ONES AT EDGES OF SOME CONTINENTS AND UNDER HIGH MOUNTAINS.

- 178 01:27:40:13 THESE EARTHQUAKES REVEAL THE LITHOSPHERE IS FRACTURED LIKE A GIANT EGGSHELL INTO SOME 20 HUGE SLABS OR PLATES.
- 179 01:27:49:27 HERE, THE AFRICAN PLATE.
- 180 01:27:52:13 THE INDIAN-AUSTRALIAN PLATE.
- 181 01:27:54:28 THE PACIFIC PLATE.
- 182 01:27:58:22 THIS LAVA LAKE SHOWS HOW THESE PLATES FLOAT ON A PARTIALLY MOLTEN LAYER BENEATH THE LITHOSPHERE.
- 183 01:28:07:01 THE CONTINENTS DON'T PLOW THROUGH HARD OCEAN FLOORS AS WEGENER'S CRITICS CLAIMED, BUT RIDE LIKE PASSENGERS EMBEDDED IN THESE FLOATING RAFTS.
- 184 01:28:21:01 THE PLATES INTERACT IN FOUR WAYS.
- 185 01:28:24:01 SOME SPREAD APART AT MID-OCEAN RIDGES.
- 186 01:28:28:06 SOME GRIND PAST EACH OTHER.
- 187 01:28:31:15 THOSE CARRYING CONTINENTS COLLIDE.
- 188 01:28:34:10 SOME SLIDE BENEATH EACH OTHER.
- 189 01:28:37:01 THIS CEASELESS MOVEMENT BUILDS THE EARTH'S SURFACE.
- 190 01:28:40:16 FOR THOSE WHO LIVE ON PLATE EDGES, THE RESULTS CAN BE DEVASTATING.
- 191 01:28:50:11 THIS EXTRAORDINARY FILM OF AN EARTHQUAKE IN JAPAN WAS CAPTURED IN MAY 1983.
- 192 01:29:04:17 BUT THE TECTONIC DRAMA BEGINS IN THE 5-MILE DEEP OCEAN TRENCHES THAT RING THE WESTERN PACIFIC.
- 193 01:29:13:03 THE WESTWARD-MOVING PACIFIC PLATE SINKS BENEATH ASIA, BEGINNING A VIOLENT JOURNEY BACK INTO THE HOT INTERIOR, A PROCESS CALLED SUBDUCTION.
- 194 01:29:24:27 JAPAN, ONE OF THE MOST EARTHQUAKE-RIDDLED PLACES IN THE WORLD, COPES WITH ALIEN FORCES

THAT INVADE AT WILL.

195 01:29:34:12 TOKYO ALONE HAS BEEN DEVASTATED NEARLY ONCE A CENTURY FOR THE PAST 2,000 YEARS.

196 01:29:46:18 AS THE PLATE THAT WAS ONCE PACIFIC SEA FLOOR DIVES SOME 50 MILES BENEATH JAPAN, IT BEGINS TO MELT.

197 01:29:56:18 FROM THIS SUBTERRANEAN DESTRUCTION COMES NEW LAND AS HOT MAGMA RISES TO FUEL JAPAN'S MANY VOLCANOES.

198 01:30:05:08 APRIL 1973.

199 01:30:07:28 AN UNDERSEA VOLCANO EXPLODES OFF THE SOUTH COAST OF JAPAN.

200 01:30:15:03 SCIENTISTS FROM THE TOKYO INSTITUTE OF TECHNOLOGY OBSERVE THE EXPLOSION.

201 01:30:19:27 NEW ISLANDS ARE BORN, CREATED BY THE PLATE DESTRUCTION IN JAPAN'S SUBDUCTION ZONE.

202 01:30:33:27 JAPAN HAS BEEN CALLED THE LAND OF LIVING VOLCANOES, ITS HISTORY A CHRONICLE OF TRAGEDY.

203 01:30:41:17 YET ITS PEOPLE SEEM TO KNOW THAT THEIR LAND OWES ITS EXISTENCE TO VOLCANOES.

204 01:30:48:12 WITH STOIC RESOLVE, THEIR LIFE GOES ON.

205 01:30:51:23 THE JAPANESE HAVE LEARNED TO LIVE WITH THIS ENDLESS CYCLE OF DESTRUCTION AND REBIRTH.

206 01:31:05:09 ALONG THE SOUTHERN EDGE OF THE ASIAN MAINLAND ARE INDIA AND THE TIBETAN PLATEAU, PUNCTUATED BY THE HIMALAYA MOUNTAINS.

207 01:31:14:19 29,000 FEET ABOVE SEA LEVEL, MARINE LIFE FOSSILS ARE PRESERVED IN THE ROCKS.

208 01:31:20:24 THEY TELL OF ANOTHER PLATE BOUNDARY WHERE CONTINENTS COLLIDE.

209 01:31:25:10 MORE THAN 40 MILLION YEARS AGO, NORTHWARD MOVEMENT OF THE PLATE CARRYING INDIA CRASHED

- INTO ASIA, AND THE HIMALAYAS WERE BORN.
- 210 01:31:36:05 SEA ROCK WAS PUSHED TO THE ROOF OF THE WORLD.
- 211 01:31:41:04 THE FORMER ISLAND CONTINENT IS THRUST UNDER ASIA, CREATING THE TIBETAN PLATEAU, THE HIGHEST AVERAGE LANDMASS IN THE WORLD.
- 212 01:31:50:20 TODAY, THE IMPACT CONTINUES, PUSHING MOUNT EVEREST EVER HIGHER.
- 213 01:31:55:13 SO INTENSE IS THE COLLISION THAT FOR THOUSANDS OF MILES INLAND, THE ASIAN CONTINENT IS BEING PUSHED ASIDE, CREATING POWERFUL UNSEEN FORCES THAT CAN STRIKE WITHOUT WARNING.
- 214 01:32:15:06 THE PEOPLE'S REPUBLIC OF CHINA CONTAINS NEARLY A BILLION PEOPLE.
- 215 01:32:20:10 FOR CENTURIES, THE CHINESE HAVE ATTEMPTED TO PREDICT EARTHQUAKES, BUT STILL THE EARTH CAN SURPRISE.
- 216 01:32:31:21 THESE SELDOM SEEN CHINESE MOTION PICTURES RECORD THE CITY OF TANGSHAN IN NORTHEASTERN CHINA AFTER THE MORNING OF JULY 28, 1976.
- 217 01:32:42:22 RAVAGED BY A COLOSSAL EARTHQUAKE, 20 SQUARE MILES COLLAPSED IN TOTAL RUIN.
- 218 01:32:49:06 AS MANY AS THREE QUARTERS OF A MILLION PEOPLE DIED, EQUIVALENT TO DESTRUCTION OF CITIES THE SIZE OF SAN FRANCISCO OR MEMPHIS.
- 219 01:32:59:12 IT WAS THE WORLD'S MOST DESTRUCTIVE EARTHQUAKE IN 400 YEARS, BORN OF FORCES OVER 2,000 MILES AWAY, WHERE INDIA RELENTLESSLY DRIVES INTO AND BENEATH ASIA IN A DRAMATIC DISPLAY OF PLATE TECTONICS.
- 220 01:33:18:23 ANOTHER KIND OF PLATE EDGE IS MARKED BY THE SAN ANDREAS FAULT ON CALIFORNIA'S COAST.
- 221 01:33:26:13 THE PACIFIC PLATE MOVES VIOLENTLY PAST THE NORTH AMERICAN PLATE.

- 222 01:33:31:09 APRIL 18, 1906.
- 223 01:33:34:06 IN A SINGLE MINUTE, THE PACIFIC PLATE LURCHED 20 FEET NORTHWARD, RELEASING ENERGY THAT HAD BEEN BUILDING FOR A CENTURY.
- 224 01:33:43:07 THE EARTHQUAKE AND FIRES DESTROYED MUCH OF SAN FRANCISCO.
- 225 01:33:53:02 TODAY, CALIFORNIA'S SAN ANDREAS IS AMONG THE WORLD'S MOST STUDIED FAULTS.
- 226 01:33:59:11 A SPECIALLY EQUIPPED NASA JET ALLOWS US TO SEE SOME OF ITS MOST STRIKING FEATURES FROM THE AIR.
- 227 01:34:18:19 ALONG CENTRAL CALIFORNIA'S CARRIZO PLAIN, THE FAULT CLEARLY MARKS THE EDGE BETWEEN THE PACIFIC PLATE ON THE LEFT AND THE NORTH AMERICAN PLATE ON THE RIGHT.
- 228 01:34:31:26 A BOUNDARY BETWEEN TWO PLATES IS DRAMATICALLY VISIBLE, THE SCAR OF A GREAT TECTONIC CONTEST, AS THE STRENGTH OF ROCK OF ONE PLATE IS PITTED AGAINST THE STRENGTH OF ANOTHER.
- 229 01:34:48:13 THE FAULT EXTENDS FROM BENEATH THE SEA, BEGINNING WHERE BAJA CALIFORNIA HAS BEEN SPLIT FROM MEXICO, RUNS UP ON LAND, AND SPLINTERS CALIFORNIA IN TWO FOR A THOUSAND MILES.
- 230 01:35:01:26 DESPITE POPULAR MISCONCEPTION, CALIFORNIA WON'T SINK INTO THE PACIFIC.
- 231 01:35:06:27 INSTEAD, IT WILL SLIDE NORTHWARD.
- 232 01:35:09:12 IN 15 MILLION YEARS, LOS ANGELES WILL BE SAN FRANCISCO'S SUBURB.
- 233 01:35:14:27 THE GIANTS AND DODGERS COULD AGAIN BE CROSS-TOWN RIVALS.
- 234 01:35:22:27 TODAY, THE TECTONIC STRUGGLE CONTINUES.
- 235 01:35:25:22 IN CITIES LIKE HOLLISTER, FORCES ARE RELEASED SLOWLY AND WITHOUT VIOLENCE THROUGH THE

GRADUAL CREEP OF THE PLATES.

- 236 01:35:35:01 BUT IN CONTRAST, JUST NORTH ALONG LAKES ATOP THE FAULT, TWO PLATES ARE STICKING, EACH DAY BUILDING OMINOUS STRESS.
- 237 01:35:48:08 THE SAN ANDREAS FAULT RUNS THROUGH THE SAN FRANCISCO PENINSULA, OUT TO SEA, THEN SKIRTS THE CALIFORNIA COAST FOR 300 MILES.
- 238 01:36:06:00 AS SCIENTISTS CONTINUE TO MONITOR THE STATE, THE CITIES ALONG THE FAULT WILL CONTINUE TO WATCH AND TO WAIT, ASKING NOT WHETHER, BUT WHEN AND WHERE.
- 239 01:36:24:04 AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY, COMPUTERS MODEL THE EARTH'S INTERIOR TO BETTER UNDERSTAND THE FORCES THAT KEEP THE PLATES IN CONSTANT MOTION.
- 240 01:36:36:19 GEOPHYSICIST DON ANDERSON.
- 241 01:36:38:19 WE'VE GOT NO IDEA WHAT DRIVES THE PLATES, HOW DEEP THE CONTINENTS EXTEND, HOW DEEP MID-OCEAN RIDGES ARE -- THE BASIC FUNDAMENTAL QUESTIONS OF PLATE TECTONICS AND GEOPHYSICS WE DON'T HAVE THE ANSWERS TO YET.
- 242 01:36:56:00 WE'VE BEEN BUSY DESCRIBING THE PHENOMENON.
- 243 01:37:01:02 SEARCHING INTO THIS COMPLEX FRONTIER OF GEOPHYSICS ARE BRAD HAGER AND ROBERT CLAYTON.
- 244 01:37:11:27 THE WORLDWIDE SEISMIC NETWORK RECORDS THE THOUSANDS OF EARTHQUAKES THAT ROCK THE EARTH EACH YEAR.
- 245 01:37:19:16 THEY'RE A TOOL FOR LOOKING INSIDE THE EARTH.
- 246 01:37:23:01 FROM THESE WAVES, SCIENTISTS INFER THE DENSITY AND EVEN TEMPERATURE OF THE DEEP ROCK.
- 247 01:37:30:01 CLAYTON HAS PRODUCED SOME OF THE FIRST THREE-DIMENSIONAL MAPS OF THE EARTH'S INTERIOR.

- 248 01:37:37:16 THESE 100-KILOMETER SLICES SHOW THE DRAMATIC VARIATION BETWEEN HOTTER REGIONS, IN RED, AND COLDER REGIONS, IN BLUE, IN THE SUBTERRANEAN LAYERS CALLED THE MANTLE.
- 249 01:37:49:17 THESE MAPS REVEAL AN INTERIOR MORE COMPLEX THAN WE EVER IMAGINED.
- 250 01:37:54:16 WE BELIEVE CONVECTION CURRENTS IN THE MANTLE DRIVE PLATE TECTONICS AND THAT UPWELLING CURRENTS DRIVE THE PLATES.
- 251 01:38:02:18 WHEN THE OCEANIC LITHOSPHERE GETS VERY OLD, IT SINKS BACK INTO THE MANTLE.
- 252 01:38:08:18 WE HAVE THEORIES AS TO HOW DEEP THESE PHENOMENA EXTEND, BUT THEY'RE JUST THEORIES UNTIL WE ACTUALLY HAVE THE RAW DATA.
- 253 01:38:18:04 IN ANOTHER COMPUTER DEMONSTRATION, BRAD HAGER SIMULATES CONVECTION THROUGH A CROSS SECTION OF THE EARTH'S MANTLE.
- 254 01:38:26:17 IN THIS MODEL, THE SOLID ROCK OF THE EARTH'S INTERIOR, DRIVEN BY RADIOACTIVE HEATING, FLOWS LIKE A LIQUID OVER GEOLOGIC TIME.
- 255 01:38:36:28 EACH CYCLE TAKING SECONDS ON A COMPUTER TAKES A HALF BILLION YEARS INSIDE THE EARTH.
- 256 01:38:44:18 A NEW FRONTIER OPENS.
- 257 01:38:46:19 SCIENCE IS JUST BEGINNING TO UNDERSTAND JAMES HUTTON'S HEAT ENGINE THAT CONSTANTLY RECONSTRUCTS THE EARTH'S SURFACE.
- 258 01:39:00:25 KILAUEA VOLCANO ON THE ISLAND OF HAWAII.
- 259 01:39:04:04 A POWERFUL TESTAMENT TO THE PARADOX OF CREATION AND DESTRUCTION.
- 260 01:39:11:20 MUCH OF HAWAII'S LEGEND GROWS FROM THIS STRIKING SPECTACLE.
- 261 01:39:17:05 THE FIRE GODDESS PELE LIVES HERE BENEATH THE MOLTEN FLOOD.
- 262 01:39:25:28 BUT FOR SCIENTISTS, THE VOLCANO IS A WINDOW ON

THE INTERIOR.

- 263 01:39:31:18 IT IS A REVEALING GEOLOGICAL LABORATORY.
- 264 01:39:39:06 LOCATED IN THE MIDDLE OF THE PACIFIC PLATE, KILAUEA IS THOUSANDS OF MILES FROM A PLATE EDGE, WHERE MOST ERUPTIONS OCCUR.
- 265 01:39:55:06 HAWAII IS THE YOUNGEST OF A 2,500-MILE CHAIN OF VOLCANIC ISLANDS AND UNDERSEA MOUNTAINS THAT STRETCHES WEST TO MIDWAY ISLAND, THEN NORTH ALONG THE SUBMERGED EMPEROR SEAMOUNTS.
- 266 01:40:11:06 GEOLOGY REVEALS THAT THE ISLANDS GROW OLDER THE FARTHER THEY ARE FROM HAWAII.
- 267 01:40:18:01 WHAT CAUSES THIS UNIQUE CHAIN OF VOLCANOES TO FORM IN THE MIDDLE OF THE PACIFIC PLATE?
- 268 01:40:26:09 IN A REMOTE AREA OF THE BIG ISLAND, SCIENTISTS FROM THE U.S. GEOLOGICAL SURVEY'S HAWAII VOLCANO OBSERVATORY BEGIN AN UNUSUAL TASK.
- 269 01:40:44:21 THE LAVA OF KILAUEA HOLDS A FASCINATING TALE.
- 270 01:40:48:14 TO UNLOCK THE STORY, GEOLOGISTS ED WOLFE AND TINA NEAL CAPTURE THE MOLTEN ROCK WHILE IT'S STILL HOT.
- 271 01:40:57:08 RIGHT HERE.
- 272 01:40:58:21 YOU GOT THE GLOVE?
- 273 01:41:00:23 THEY ARE ARMED FOR DANGEROUS WORK.
- 274 01:41:03:22 IN ANOTHER AGE, THEY MIGHT HAVE BEEN KNIGHTS RIDING FORTH AGAINST DEMONS OR DRAGONS.
- 275 01:41:11:27 100, 300.
- 276 01:41:13:08 400, 450.
- 277 01:41:15:08 [TINA NEAL] SOMETIMES I'M SCARED OUT THERE.
- 278 01:41:18:13 SOMETIMES MY HEART BEATS FAST.
- 279 01:41:20:28 I'D BE WORRIED IF IT DIDN'T.

- 280 01:41:23:27 AT FIRST I WENT FROM BEING FRANTIC AT WALKING ON LAVA I KNEW WAS TWO HOURS OLD TO BEING ABLE TO DO THAT ROUTINELY.
- 281 01:41:35:22 BUT WE DO TAKE PRECAUTIONS.
- 282 01:41:47:08 CAN YOU GO BACK AND GET THE ASBESTOS GLOVE?
- 283 01:41:55:12 TIME IS CRUCIAL.
- 284 01:41:57:12 AS THE 2,000-DEGREE LAVA BEGINS TO COOL, ITS CHEMISTRY CHANGES.
- 285 01:42:03:09 TELLTALE GASES ARE LOST, ERASING SECRETS OF ITS ORIGIN AND COMPOSITION.
- 286 01:42:08:24 WATER COOLS THE LAVA, TURNS IT TO GLASS, AND FREEZES ITS MESSAGE IN TIME.
- 287 01:42:15:25 THIS IS AS CLOSE TO THE EARTH'S DEEP MAGMA AS SCIENTISTS CAN GET.
- 288 01:42:22:17 UNLIKE VOLCANOES ON PLATE BOUNDARIES, KILAUEA'S LAVA CONTAINS UNTOUCHED ELEMENTS FROM A SOURCE TWO BILLION YEARS OLD.
- 289 01:42:39:19 SCIENTISTS SUSPECT THAT KILAUEA RIDES ATOP A STATIONARY THERMAL PLUME THEY CALL A HOT SPOT, WITH ROOTS PERHAPS AS DEEP AS 2,000 MILES INTO THE EARTH'S INTERIOR.
- 290 01:42:55:03 AS THE PLATE MOVES OVER THIS RISING PLUME OF MOLTEN ROCK, ONE VOLCANO AFTER ANOTHER IS BUILT.
- 291 01:43:03:12 HAWAIIITSELF IS MOVING OFF THE SPOT.
- 292 01:43:07:01 19 MILES SOUTH, A NEW VOLCANO, LOIHI, HAS RISEN 8,000 FEET ABOVE THE SEA FLOOR, STILL 3,000 FEET BELOW SEA LEVEL.
- 293 01:43:16:25 IT WILL BE THE NEXT HAWAIIAN ISLAND IN A LONG CHAIN, EVIDENCE OF THE RELENTLESS DRIFT OF THE PACIFIC PLATE.
- 294 01:43:31:10 THE MISSISSIPPI RIVER, SITE OF THE LARGEST EARTHQUAKE IN AMERICAN HISTORY, 20 TIMES MORE POWERFUL THAN SAN FRANCISCO'S DEVASTATING

1906 QUAKE.

- 295 01:43:42:26 IN THE WINTER OF 1811-1812, THREE MASSIVE QUAKES CHANGED THE RIVER'S COURSE AND ALTERED THE LANDSCAPE FOR HUNDREDS OF MILES.
- 296 01:43:53:12 THE EARTHQUAKES WERE CENTERED NEAR THE MISSISSIPPI VALLEY TOWN OF NEW MADRID, MISSOURI, ONCE GATEWAY TO THE WEST.
- 297 01:44:02:28 NEW MADRID IS A PEACEFUL MIDWESTERN COMMUNITY.
- 298 01:44:06:27 BUT IN 1812, IT DISAPPEARED.
- 299 01:44:16:28 JAMES CRAVEN, MAYOR OF NEW MADRID.
- 300 01:44:19:27 THIS IS A GOOD SPOT TO SEE WHERE THE OLD TOWN WAS BECAUSE IT'S IN THE MIDDLE OF THE RIVER.
- 301 01:44:29:28 SOMETIME AFTER 1812, AFTER THE EARTHQUAKES, THE RIVER CHANNEL MOVED OVER, CUTTING AWAY INTO THE TOWN.
- 302 01:44:38:03 IF YOU COULD JUST IMAGINE ANOTHER, SAY, FIVE MILES STRAIGHT THROUGH THERE IS REALFOOT LAKE.
- 303 01:44:46:28 IT'S REALLY THE ONLY EVIDENCE OF THE EARTHQUAKE.
- 304 01:44:51:03 THERE'S NOT ANY BIG CRACKS IN THE GROUND.
- 305 01:44:55:03 PEOPLE WANT TO SEE EVIDENCE OF THE EARTHQUAKE.
- 306 01:44:59:03 THERE'S NOTHING TO SAY EXCEPT, "HANG AROUND.
- 307 01:45:02:15 MAYBE YOU'LL GET IN THE MIDDLE OF ONE." AT THE EBASCO CORPORATION, AN ENGINEERING FIRM IN NEW YORK CITY, DR. OTTO NUTTLI OF ST. LOUIS UNIVERSITY AND GEOLOGIST FRED SNYDER EXPLORE THE NEW MADRID EARTHQUAKE BY COMPUTER.
- 308 01:45:25:11 WHAT CAUSED THIS MASSIVE DISASTER HUNDREDS OF MILES FROM A PLATE EDGE, WHERE MOST EARTHQUAKES OCCUR?

- 309 01:45:33:09 HERE'S THE CITY OF NEW MADRID ON THE MISSISSIPPI RIVER.
- 310 01:45:37:27 LET'S TURN ON THE THREE BIGGEST EARTHQUAKES THAT OCCURRED IN THE AREA.
- 311 01:45:44:11 WE'VE TAKEN OVER 2,000 EARTHQUAKES RECORDED IN THIS AREA FROM 1974 THROUGH 1983 AND PUT THEM INTO THE COMPUTER.
- 312 01:45:54:06 EACH CROSS REPRESENTS A SINGLE EARTHQUAKE.
- 313 01:45:57:05 COMPUTER PLOTTING OF RECENT EARTHQUAKES PROVIDES UNIQUE CLUES TO THE PAST.
- 314 01:46:03:03 170 YEARS AFTER MASSIVE QUAKES, THE NEW MADRID ZONE IS STILL ALIVE.
- 315 01:46:08:17 WE CAN LOOK AT THESE EARTHQUAKES IN THREE DIMENSIONS NOW.
- 316 01:46:17:18 THE DISTRIBUTION OF EARTHQUAKES OUTLINES FAULT PLANES, LONGER AND DEEPER THAN PREVIOUSLY THOUGHT.
- 317 01:46:24:25 BECAUSE GREAT FORCE IS REQUIRED TO BREAK ROCK AT SUCH DEPTHS, THESE DEEP FAULTS CONCERN THE SCIENTISTS.
- 318 01:46:33:03 THIS HELPS US UNDERSTAND HOW THE FAULT IS BEING REACTIVATED.
- 319 01:46:40:02 600 MILLION YEARS AGO, THE NORTH AMERICAN INTERIOR WAS NEITHER FLAT NOR QUIET.
- 320 01:46:46:17 THE CONTINENT WAS TEARING APART ALONG A GREAT RIFT.
- 321 01:46:51:02 THEN IT STOPPED.
- 322 01:46:52:18 TIME HAS HEALED THE GREAT GASH.
- 323 01:46:55:17 INCREASING EAST-WEST COMPRESSION ON THE FAULT ZONE MAY REOPEN THE ANCIENT WOUND.
- 324 01:47:02:01 THIS GIVES US A PHYSICAL MODEL OF THE CAUSE OF THE NEW MADRID EARTHQUAKES.
- 325 01:47:09:21 IN THE 1811-1812 EARTHQUAKES, FEW LIVES WERE

LOST.

- 326 01:47:15:25 TODAY, SOME 7 STATES AND 12 MILLION PEOPLE WOULD BE AFFECTED.
- 327 01:47:24:05 CITIES LIKE ST. LOUIS AND MEMPHIS ARE BEGINNING TO CONSIDER NEW MADRID'S DESTRUCTIVE PAST IN PLANNING FOR THE FUTURE.
- 328 01:47:40:19 ELSEWHERE, ANOTHER NEW FRONTIER OF CONTINENTAL TECTONICS CONFRONTS SCIENCE.
- 329 01:47:45:19 THE FAMED GOLDEN GATE BRIDGE LINKS THE MARIN HEADLANDS TO THE CITY OF SAN FRANCISCO.
- 330 01:47:53:05 TO TOURISTS, IT IS A LANDMARK, BUT FOR SCIENTISTS, IT'S A FOOTBRIDGE TO A FOREIGN LAND.
- 331 01:48:02:06 BONNIE MURCHIE, DAVID HOWELL, AND DAVEY JONES OF THE U.S. GEOLOGICAL SURVEY ARE PIONEERS OF A REVOLUTIONARY NEW THEORY ABOUT THE ASSEMBLY OF CONTINENTS CALLED MICROPLATE TECTONICS.
- 332 01:48:17:06 BY STUDYING MARINE FOSSILS LOCKED IN ROCKS OF THE MARIN HEADLANDS, THEY'VE DISCOVERED THAT ALL-AMERICAN SAN FRANCISCO CAME FROM SOMEPLACE ELSE.
- 333 01:48:27:16 A PALEONTOLOGY PROFESSOR SAID IF YOU LICK ROCKS, YOU COULD GET SOME -- TERRIBLE DISEASE.
- 334 01:48:35:02 WE'VE ALL GOT IT.
- 335 01:48:37:21 PRIMITIVE ONE-CELLED ORGANISMS CALLED RADIOLARIA THRIVE IN THE SEA.
- 336 01:48:43:01 LIKE MYRIAD INVISIBLE PLANKTON, THEIR SKELETONS DRIFT TO THE OCEAN BOTTOM WHEN THEY DIE, FORMING PART OF THE SEDIMENTARY ROCK.
- 337 01:49:05:08 ??
- 338 01:49:05:08 SIMILAR TO OPAL AND QUARTZ IN CHEMICAL COMPOSITION, RADIOLARIA ARE REMARKABLE FOR THEIR SYMMETRY AND DELICATE BEAUTY.
- 339 01:49:14:09 THEY HAVE BEEN LIKENED TO LIVING SNOWFLAKES.

- 340 01:49:28:09 AN ACID BATH TECHNIQUE ETCHES AWAY THE SOLID ROCK.
- 341 01:49:32:09 THE HARDER SHELLS ARE RELEASED TO TELL THEIR AMAZING STORY, FREE FROM THE BONDAGE OF 100 MILLION YEARS.
- 342 01:49:46:24 THE ABUNDANCE AND VARIETY OF THESE SHELLS IS A PRODUCT OF OCEAN ENVIRONMENT.
- 343 01:49:53:16 FROM ANALYSIS OF THESE ONCE LIVING JEWELS, BONNIE MURCHIE DETERMINES THE AGE OF A FRAGMENT OF FORMER SEDIMENT, AT WHAT DEPTH IT WAS FORMED, AND ITS PROBABLE GEOGRAPHIC LOCATION IN THE DISTANT PAST.
- 344 01:50:10:08 COMPARING THESE ENVIRONMENTAL ARTIFACTS TELLS OF RICH HISTORY.
- 345 01:50:14:23 THE ELECTRON MICROSCOPE REVEALS FINER DETAIL.
- 346 01:50:19:09 GO DOWN TO THE NEXT ONE.
- 347 01:50:24:23 OH, THAT'S GOOD.
- 348 01:50:26:22 FROM THIS SMALL OBJECT COMES A PROVOCATIVE THEORY ABOUT THE FORCES THAT SHAPE ENTIRE CONTINENTS.
- 349 01:50:36:09 THESE FOSSILS SUGGEST THAT THE PIECE OF LAND ANCHORING THE GOLDEN GATE BRIDGE WAS FORMED SEVERAL THOUSAND MILES TO THE SOUTH.
- 350 01:50:46:23 SOME SCIENTISTS NOW BELIEVE THAT SAN FRANCISCO WAS BUILT FROM "EXOTIC TERRAIN," CHUNKS OF LAND THAT HAVE MIGRATED FROM SOMEWHERE ELSE.
- 351 01:50:57:18 WHILE THE MARIN HEADLANDS CAME FROM THE DEEP OCEAN, ALCATRAZ ISLAND IN SAN FRANCISCO FORMED IN THE MARGINS OF ANOTHER CONTINENT.
- 352 01:51:09:05 ANGEL ISLAND WAS BORN BY A COLLISION OR IN A SUBDUCTION ZONE.
- 353 01:51:14:24 MOST OF THIS CENTRAL STRIP ACTUALLY FORMED IN THE OCEAN AND WAS ACCRETED TO THE

CONTINENTAL MARGIN.

- 354 01:51:23:10 THE 10 TERRAINS WE'VE SEEN IN THE SAN FRANCISCO BAY REGION, THEIR CHARACTER CAN NOW BE SHOWN TO DESCRIBE TERRAIN DISTRIBUTION THROUGHOUT WESTERN NORTH AMERICA.
- 355 01:51:35:25 WE HAVE DISCOVERED 200 TERRAINS, SUCH THAT THE CONTINENT HAS GROWN BY AT LEAST 25%.
- 356 01:51:44:10 DEEP OCEANIC ROCKS IN IDAHO.
- 357 01:51:47:09 EXOTIC MICROCONTINENTS IN THE CANADIAN ROCKIES.
- 358 01:51:51:10 CORAL ATOLLS NOW ATOP MOUNTAINS IN ALASKA.
- 359 01:51:55:15 IN SOUTHERN ASIA, NEW DISCOVERIES HINT THAT OTHER BLOCKS OF LAND PRECEDED INDIA IN ITS COLLISION WITH ASIA.
- 360 01:52:04:12 AN INTRIGUING NEW CHAPTER EMERGES IN THE STORY OF PLATE TECTONICS.
- 361 01:52:09:28 WHERE THESE TERRAINS CAME FROM AND HOW THEY GOT WHERE THEY ARE WILL CHALLENGE SCIENCE FOR DECADES.
- 362 01:52:20:27 THE VAST POWER OF THE COMPUTER HAS ALLOWED CHRISTOPHER SCOTESE OF THE UNIVERSITY OF TEXAS TO RECONSTRUCT WHOLE CHAPTERS OF EARTH'S INTRIGUING PAST.
- 363 01:52:32:15 MY WORK IS REALLY A FULFILLMENT OF A CHILDHOOD FANTASY TO TRAVEL BACK IN TIME.
- 364 01:52:39:27 WE'RE USING INTERACTIVE GRAPHICS TO PEEK BACK INTO TIME AND SEE WHAT THE CONTINENTS WERE DOING MILLIONS OF YEARS AGO.
- 365 01:52:49:27 IT'S LIKE A SECOND VOYAGE OF COLUMBUS, BUT IT'S A VOYAGE IN TIME.
- 366 01:52:56:12 GEOLOGICAL DATA ABOUT ANCIENT LATITUDINAL POSITIONS IS PROCESSED TO SCIENTIFICALLY RECONSTRUCT THE CONTINENTS.

- 367 01:53:04:14 250 MILLION YEARS AGO, THE WORLD WAS THE GIANT LANDMASS OF PANGAEA, MUCH AS ALFRED WEGENER ENVISIONED IT 70 YEARS AGO.
- 368 01:53:14:26 AFRICA AND SOUTH AMERICA FIT EASILY.
- 369 01:53:17:15 NORTH AMERICA OVERLAPS, POSSIBLY BECAUSE EXOTIC TERRAINS HAVE SINCE CHANGED ITS SHAPE.
- 370 01:53:24:05 MANY MYSTERIES ARE SOLVED BY SHOWING HOW THE CONTINENTS MOVED ABOUT THE GLOBE THROUGH TIME.
- 371 01:53:31:15 ROTATING FROM THE EQUATOR TO THE SOUTH POLE, IT BECOMES CLEAR WHY THE SAHARA CONTAINS EVIDENCE OF GLACIERS.
- 372 01:53:39:29 AFRICA WAS ONCE IN A POLAR REGION, JUST AS ANTARCTICA IS NOW.
- 373 01:53:45:15 ONE IMPORTANT THING WE'RE LEARNING BY GOING THROUGH THIS EXERCISE IS THAT PLATE TECTONICS IS A GLOBAL PROCESS, AND IT AFFECTS CLIMATOLOGY, MOUNTAIN BUILDING, AND POSSIBLY EVEN EVOLUTION.
- 374 01:54:06:02 THIS TURTLE IS ON A 1,200-MILE JOURNEY.
- 375 01:54:10:01 EACH YEAR, GREEN TURTLES SWIM FROM BRAZIL TO A TINY NESTING GROUND IN THE MIDDLE OF THE ATLANTIC OCEAN.
- 376 01:54:20:02 THEIR DESTINATION IS A VOLCANIC PEAK.
- 377 01:54:23:02 THE BARREN ROCK OF ASCENSION ISLAND IS THE SETTING FOR ONE OF THE MOST REMARKABLE DRAMAS IN EVOLUTION.
- 378 01:54:36:26 DR. ARCHIE CARR, A ZOOLOGIST AT THE UNIVERSITY OF FLORIDA, HAS STUDIED GREEN TURTLE MIGRATION FOR 30 YEARS.
- 379 01:54:47:00 IT'S EASY TO SEE WHY TURTLES NEST ON ISLANDS.
- 380 01:54:51:17 THERE ARE NOT MANY PREDATORS ON ISLANDS.
- 381 01:54:55:02 JAGUARS USED TO ROAM THE SHORES OF BRAZIL.

- 382 01:54:59:01 THEY WOULD EAT THE ADULTS NESTING, THE YOUNG, AND THE EGGS.
- 383 01:55:04:18 OTHER CARNIVORES DO THE SAME.
- 384 01:55:07:04 BUT WHY DO THEY GO TO SUCH A DISTANT ISLAND?
- 385 01:55:12:04 HOW DID IT EVER EVOLVE?
- 386 01:55:14:18 IT WASN'T UNDER PRESENT GEOGRAPHIC CONDITIONS.
- 387 01:55:18:18 PLATE TECTONICS HAS GIVEN AN EXPLANATION OF HOW THIS THING COULD HAVE SLOWLY BEEN ACQUIRED WITHOUT KILLING THEM ALL WITH THE EFFORT.
- 388 01:55:29:24 AS AFRICA AND SOUTH AMERICA SPLIT, A SUCCESSION OF ISLANDS EMERGED, THEN DISAPPEARED.
- 389 01:55:36:02 AS THE OCEAN GREW WIDER, THE DISTANCE TO NEW ISLANDS GREW LONGER.
- 390 01:55:45:04 GRADUALLY LEARNED OVER MILLIONS OF YEARS, THESE HATCHLINGS WILL SWIM MUCH FARTHER THAN THEIR DISTANT ANCESTORS, FARTHER THAN THOSE WHO BROUGHT THEM HERE.
- 391 01:55:59:03 IF ARCHIE CARR IS RIGHT, PLATE TECTONICS MAY HAVE SHAPED THE GENETIC CODE OF THE GREEN TURTLE.
- 392 01:56:05:29 THE DRIFTING OF CONTINENTS MAY HAVE PROGRAMMED LIFE ITSELF.
- 393 01:56:16:06 AND SO THE SEARCH CONTINUES TO LEARN HOW EARTH'S INTERNAL HEAT ENGINE DRIVES THE PLATES ACROSS THE FACE OF THE PLANET, TO DISCOVER EARTH'S VAST AND COMPLEX HISTORY AS REVEALED IN THE ROCKS...
- 394 01:56:35:19 TO INVESTIGATE OUR LIVING MACHINE AND ITS ENDLESS CYCLES OF CREATION AND DESTRUCTION.
- 395 01:56:42:19 NEW TOOLS AND TECHNOLOGY IN SPACE ALLOW US TO SEE IN NEW WAYS, TO CONTINUE THE REDISCOVERY OF PLANET EARTH.

- 396 01:56:51:20 THE MORE WE LEARN, THE MORE WE WANT TO KNOW.
- 397 01:56:56:20 THE WORDS OF T.S. ELIOT AMPLIFY THE SCIENTIFIC PARADOX -- "WE SHALL NOT CEASE FROM EXPLORATION, "AND THE END OF OUR EXPLORING "WILL BE TO ARRIVE WHERE WE STARTED AND KNOW THE PLACE FOR THE FIRST TIME." CAPTIONING PERFORMED BY THE NATIONAL CAPTIONING INSTITUTE, INC CAPTIONS COPYRIGHT 1986 METROPOLITAN PITTSBURGH PUBLIC BROADCASTING, INC.
- 398 01:58:37:28 FOR INFORMATION CONCERNING THE *PLANET EAR* Annenberg Media
- 399 01:58:41:12 §
- 400 01:58:46:19 For information about this and other Annenberg Media programs call 1-800-LEARNER and visit us at www.learner.org.