FUNDING FOR THIS PROGRAM
IS PROVIDED BY ANNENBERG/CPB,

TO ADVANCE EXCELLENT TEACHING.

Argow: IN THE MIDDLE
OF THE PACIFIC OCEAN,

2,000 MILES
FROM THE NEAREST LANDMASS,

LIES A STRING OF ISLANDS

MADE FAMOUS
BY ITS TROPICAL CLIMATES,

CRYSTAL WATERS,

AND LUSH RAINFORESTS.

THESE ARE THE ISLANDS OF HAWAII.

ALL OF THE ISLANDS
POSSESS EVIDENCE

THAT VOLCANOES ONCE ERUPTED
ON THEM.

BUT TODAY,
ONLY ONE OF THE ISLANDS

IS HOME TO AN ACTIVE VOLCANO.

WHAT HAPPENED?

WHAT SHUT DOWN
THE HAWAIIAN VOLCANOES?

AND WHAT DOES IT TELL US ABOUT HOW THE EARTH FUNCTIONS?

WELCOME TO SESSION 4

OF "ESSENTIAL SCIENCE FOR TEACHERS -- EARTH AND SPACE."

I'M BRITT ARGOW, A GEOLOGIST
AT BOSTON UNIVERSITY.

IN OUR LAST SESSION,

WE JOURNEYED
TO THE EARTH'S INTERIOR,

AND WE LEARNED
ABOUT FLOWING SOLIDS,

AND HOW PARTIALLY MELTED ROCK
ALLOWS LARGE FRAGMENTS

OF THE EARTH'S SURFACE,
CALLED PLATES,

TO BE ABLE TO MOVE,
RELATIVE TO ONE ANOTHER.

IN THIS SESSION,
WE'RE GOING TO INVESTIGATE

WHY THE PLATES ARE MOVING
IN THE FIRST PLACE --

WHAT'S DRIVING
PLATE TECTONICS.

TO DO THIS,
WE'RE GOING

TO EXPLORE
THE DYNAMIC WORLD

OF VOLCANOES
AND EARTHQUAKES.

THOSE ARE SOME

OF MY STUDENTS'
FAVORITE TOPICS.

I'M JOE REILLY.

I KNOW MY SECOND-GRADE STUDENTS

HAVE ALL READ BOOKS
AND SEEN VIDEOS

ABOUT THESE OFTEN VIOLENT NATURAL PHENOMENA.

BUT DO THEY REALLY KNOW
WHAT'S HAPPENING

WHEN THEY SEE PICTURES OF, SAY,

MT. ST. HELENS ERUPTING,

OR WHEN THEY SEE NEWS FOOTAGE

OF THE AFTERMATH
OF HUGE EARTHQUAKES?

MAYBE A BETTER QUESTION IS,

DO I REALLY KNOW WHAT'S GOING ON WHEN THESE THINGS HAPPEN?

WHAT'S GOING ON INSIDE THE EARTH TO PRODUCE THESE EVENTS?

RIGHT NOW, CAN YOU ANSWER
THE FOLLOWING QUESTIONS?

AS WE EXPLORE THE WORLD
OF EARTHQUAKES AND VOLCANOES,

WE'LL DISCOVER
BOTH THE DESTRUCTIVE

AND THE CONSTRUCTIVE NATURE
OF THESE PHENOMENA.

WE'LL UNRAVEL THE HAWAIIAN VOLCANO MYSTERY,

AND WE'LL LEARN WHY MOST
OF THE ISLAND CHAIN'S VOLCANOES

NO LONGER ERUPT.

AND FINALLY, WE'LL LEARN WHY VOLCANOES AND EARTHQUAKES

ARE SO IMPORTANT
IN UNDERSTANDING

THE DYNAMICS OF PLATE TECTONICS.

SO LET'S BEGIN BY
EXPLORING VOLCANOES.

THE FIRST THING
WE'LL LEARN --

NOT ALL VOLCANOES
ARE ALIKE.

Man: IF YOU ASK SOMEBODY TO DRAW A VOLCANO ON A CHALKBOARD,

IT'S GOING TO BE
VERY STEEP SIDES,

PROBABLY APPROACHING 25, 30°,

THE CLASSIC STEEP-SIDED

CINDER-CONES THAT YOU SEE --

MT. VESUVIUS,
MT. ST. HELENS,

MT. PINATUBO, THE CLASSIC VOLCANOES OF THE EARTH

THAT EVERYBODY LOOKS AT
AND SAYS,

"OH, THAT'S A VOLCANO.
THERE'S NO DOUBT ABOUT THAT."

Argow: FROM THESE CLASSIC-LOOKING VOLCANOES

OFTEN COME CLASSIC ERUPTIONS.

Man: MOST OF OUR EXPERIENCES WITH VOLCANOES

THROUGHOUT THE WORLD ARE
WITH STEEP-SIDED VOLCANOES.

WE'VE EXPERIENCED IT OURSELVES IN OUR LIFETIMES,

THE VOLCANOES THAT ARE CATASTROPHIC IN THEIR ERUPTIONS.

MT. ST. HELENS COMES TO MIND --

THAT FATEFUL DAY IN MAY OF 1980.

NOT JUST EXPLODED,

BUT HALF THE SIDE
OF THE MOUNTAIN IS GONE.

Argow: VOLCANOLOGIST
DAVE SHERROD IS AT THE SUMMIT

OF ONE
OF THE MOST ACTIVE VOLCANOES

ON THE PLANET -- KILAUEA,
ON THE BIG ISLAND OF HAWAII.

Sherrod: SOME VOLCANOES
IN THE WORLD

EXTRUDE VAST AMOUNTS OF LAVA

AND BUILD UP SLOWLY
WITH BROAD SLOPES

TO FORM WHAT WE WOULD CALL
A SHIELD VOLCANO,

AND THAT'S THE KIND OF VOLCANO KILAUEA IS.

FOR A LOT OF FOLKS, THEY DRIVE UP FROM SEA LEVEL,

GETTING HIGHER AND HIGHER,

THEY REACH THE SUMMIT,
AND THEY LOOK AROUND AND SAY,

"WHERE'S THE VOLCANO?"

TO UNDERSTAND THAT,

WE NEED TO UNDERSTAND
THE GREAT SIZE

OF A VOLCANO LIKE KILAUEA --

ALTHOUGH WE'RE AT THE SUMMIT,

IT EXTENDS EAST OF US
OVER 40 MILES DOWN TO THE COAST,

AND THEN PROCEEDS
INTO THE SUB-SEA SETTING

AS A BROAD RIDGE
FOR ANOTHER 40 OR 50 MILES.

IT'S AN IMMENSE VOLCANO.

Argow: AN IMMENSE VOLCANO,
WHERE LAVA USUALLY BUBBLES UP

AND FLOWS ACROSS THE SURFACE
IN GREAT RIVERS OF MOLTEN ROCK.

Blay: THE HAWAIIAN ISLANDS
ARE SOMEWHAT DIFFERENT

IN THAT WHEN THEY ERUPT,
THEY DON'T EXPLODE AS MUCH.

THERE ARE EXPLOSIVE EPISODES,

BUT THE BULK OF THE MATERIAL THAT COMES OUT FLOWS OUT.

IT BUBBLES OUT.

THIS IS CALLED EFFUSION.

THESE ARE CALLED
EFFUSIVE VOLCANOES,

COMPARED WITH
EXPLOSIVE VOLCANOES.

Argow: WHEN WE COMPARE
THE EXPLOSIVE MT. ST. HELENS

AND EFFUSIVE KILAUEA,

WE SEE TWO VERY
DIFFERENTLY SHAPED

DIFFERENTLY SIZED,
AND DIFFERENT STYLES OF VOLCANO.

WHY DO THESE TWO VOLCANOES ERUPT SO DIFFERENTLY?

WHY DID THESE VOLCANOES
ERUPT AT ALL?

WE'VE ASKED SEVERAL

ELEMENTARY SCHOOL STUDENTS
TO TELL US

WHAT THEY BELIEVE
CAUSES VOLCANOES TO ERUPT.

THE MOST COMMON IDEA
WAS PRESSURE.

IN WEAK PLACES
IN THE EARTH'S CRUST,

MAYBE LIKE HERE OR HERE,

THIS STUFF HAS
A LOT OF PRESSURE,

AND IT'S ALWAYS FORCING
TO GET OUT.

THE LAVA FORMS LIKE
AT THE BOTTOM OF THE VOLCANO,

BECAUSE OF THE HOT PRESSURE THAT'S FORMING BECAUSE OF, LIKE,

BECAUSE THE VOLCANO
IS GETTING MORE,

LIKE, STRENGTH, I WOULD SAY.

THE HEAT MAKES IT EXPAND
AND MAKE BUBBLES.

AND MAKES IT GET
BIGGER AND BIGGER,

AND IT STARTS TO MELT THIS ROCK, AND IT COMES

FORWARDS INTO HERE,
BUT THERE ISN'T ANY ROOM FOR IT.

THIS IS LIKE THE LAVA PART
IN THE VOLCANO.

AND SOME OF IT MIGHT COME
FROM THE CENTER OF THE EARTH.

THIS IS LIKE
WHERE THE LAVA GOES.

AND THEN PRESSURE
WOULD BRING IT UP.

AND ONCE IT FILLS UP,

SO MUCH PRESSURE IS ON IT.

THE PRESSURE BUILDS UP
AND BUILD UP AND BUILDS UP.

AND THEN IT COMES SHOOTING OUT.

AND IT EXPLODES.

AND IT EXPLODES.

[IMITATES EXPLOSION]

Reilly: MOST OF THE STUDENTS
WE INTERVIEWED

BELIEVE THAT WHEN LAVA BUILDS UP INSIDE A VOLCANO,

THE PRESSURE INCREASES UNTIL EVENTUALLY THE VOLCANO ERUPTS.

BECAUSE THERE'S
SO MANY ERUPTIONS...

Reilly: 9-YEAR-OLD MARK
HAS A SLIGHTLY DIFFERENT IDEA.

HE BELIEVES EARTHQUAKES
CAUSE VOLCANIC ERUPTIONS.

WHEN THE VOLCANO SHAKES,

SOMETHING INSIDE OF THE MAGMA TRIGGERS THE ERUPTION.

Mark: WHEN THE EARTHQUAKE
SHAKES THE GROUND,

THERE'S BUBBLES IN THE MAGMA, WHICH CAUSES IT

TO, TO RISE AND EVENTUALLY
ERUPT THE VOLCANO.

JUST LIKE IF YOU SHAKE
A CAN OF SODA,

AND THEN OPEN IT UP,
IT WILL ALL SQUIRT OUT THE TOP.

JUST LIKE SODA,
IT WILL, IT WILL...

THE BUBBLES WILL GROW BIGGER, AND IT WILL RISE,

SO WHEN IT OPENS UP,
IT GOES EVERYWHERE.

Interviewer: DO YOU
WANT TO TRY IT?

OKAY.

THE EARTHQUAKE HAPPENS...

ALL THE FOAM CAME -- ALL OF
THE FOAM CAUSED IT TO COME OUT.

Reilly: DO YOU AGREE
WITH THE STUDENTS?

DOES A VOLCANO ERUPT BECAUSE
THE ACCUMULATION OF LAVA CREATES

A TREMENDOUS AMOUNT OF PRESSURE?

IS A VOLCANO LIKE A CAN OF SODA?

DOES IT ERUPT WHEN IT GETS SHAKEN BY AN EARTHQUAKE?

TO ANSWER THESE QUESTIONS,

WE NEED TO INVESTIGATE
THE EARTH'S INTERIOR,

TO DISCOVER WHERE LAVA COMES FROM IN THE FIRST PLACE.

Sherrod: THE EARTH IS VERY...
IS VERY BIG,

AND AS YOU GO DOWN INSIDE IT,

THE PRESSURE
OF THE OVERLYING ROCKS

PREVENT MELTING.

SO WE DON'T HAVE MELTING
DEEP IN THE EARTH; WE HAVE HEAT.

AS HEAT COMES CLOSER AND CLOSER TO THE SURFACE OF THE EARTH,

WE'RE ABLE TO PRODUCE MELTS.

WHAT DEPTH?

WELL, WE'VE GOT TO GET
PRETTY HIGH IN THE MANTLE --

UP NEAR THE MANTLE-CRUST BOUNDARY --

BEFORE WE GET PRESSURES
THAT ARE

REDUCED ENOUGH
FOR MELTING TO OCCUR.

Argow: THIS MELTED ROCK

IS MAGMA,

AND IT BEGINS TO RISE
TOWARDS THE SURFACE.

Sherrod: WELL,
IF YOU BELIEVE IN GRAVITY,

WHY WOULD MAGMA GO UP TO
THE SURFACE IN THE FIRST PLACE?

WHY DOESN'T IT STAY DOWN
IN THE EARTH WHERE IT BELONGS?

AND THE PROBLEM THERE
IS BUOYANCY.

THESE MELTS FORM AT DEPTHS
OF 100 KILOMETERS, WE THINK.

THE SEISMIC EVIDENCE SUGGESTS

THEY'RE INITIATING
FROM THAT DEEP,

BUT THEY'RE HOT MELTS,
AND THEY'RE ABLE TO RISE

WITHIN THEIR SEMI-PLASTIC SURROUNDINGS

BECAUSE THEY'RE BUOYANT.

THEY'RE HOT -- THEY ACTUALLY HAVE LOWER DENSITY

THAN THE ADJACENT WALL ROCKS.

SO THEY ARE FOLLOWING
THE LAW OF GRAVITY,

BUT THAT LAW TELLS THEM
TO RISE,

GO TO THE SURFACE,
YOUNG LAVA FLOW.

Argow: MELTED ROCK, OR MAGMA,
IS LESS DENSE THAN SOLID ROCK.

BECAUSE IT'S LESS DENSE,

IT'S MORE BUOYANT
THAN THE ROCK AROUND IT,

AND IT RISES
TOWARDS THE SURFACE.

AT SOME POINT,

THE MAGMA REACHES A DEPTH

WHERE ITS DENSITY
IS CLOSE TO THAT

OF THE ROCK THAT SURROUNDS IT.

SO IT STOPS RISING,
BUT MORE AND MORE MAGMA

IS MOVING UP INTO THE CRUST.

THIS RESERVOIR
OF ACCUMULATED MAGMA

IS KNOWN AS A MAGMA CHAMBER.

BUT HOW DOES THE MAGMA
FINALLY ERUPT?

ONE ANSWER HAS TO DO WITH DISSOLVED GASES IN THE MAGMA.

Sherrod: HEAT BRINGS MAGMA UP
NEAR THE SURFACE OF THE EARTH,

BUT IT'S GAS THAT ALLOWS IT
TO ERUPT,

BECAUSE THE GAS WANTS TO EXPAND.

THESE MELTS FORM,

THEY'RE FULL OF GAS,
AND THEY'RE KIND OF

INTO A NEUTRAL BUOYANCY ZONE WHERE THEY MIGHT BE HAPPY

JUST LODGING THEMSELVES
IN THE CRUST,

BUT THAT GAS
NOW STARTS TO EXPAND

BECAUSE THE PRESSURE'S
BEEN REDUCED ENOUGH

SO THE WATER VAPOR
INSIDE THERE,

THE CARBON DIOXIDE,
AND THE SULFUR,

THEY START
TO INCREASE THEIR VOLUME

AND CAUSE SOME OF THE MELTS
TO ACTUALLY EXPAND,

OR FROTH.

Argow: MAGMA CONTAINS GASES
LIKE WATER VAPOR,

CARBON DIOXIDE,
AND SULFUR DIOXIDE.

AS NEW MAGMA ENTERS THE CHAMBER, THE CHAMBER SWELLS.

EVENTUALLY,
THE OVERLYING ROCK

MIGHT FRACTURE
FROM THE PRESSURE.

THE SUDDEN RELEASE FORCES GASES OUT OF THE MAGMA.

ESCAPING GASES FROTH THE MAGMA,

MAKING IT LIGHT ENOUGH
TO RISE,

AND CAUSING IT
TO FOUNTAIN, OR EXPLODE,

WHEN IT REACHES
THE SURFACE.

A GOOD ANALOGY MIGHT BE
WHAT HAPPENS

WHEN YOU OPEN A CAN OF SODA
OR A BOTTLE OF SODA.

THERE'S CARBON DIOXIDE
DISSOLVED IN THAT SODA,

AND AS YOU OPEN THE TOP,
THE PRESSURE DECREASES,

WHICH IS EQUIVALENT TO MAGMA'S COMING TOWARDS THE SURFACE.

AND YOU FORM LITTLE BUBBLES
IN YOUR SODA,

JUST AS YOU FORM LITTLE BUBBLES IN LIQUID ROCKS.

AND THEN YOU GET
A VIOLENT EXPLOSION.

IN THE CASE OF MT. ST. HELENS,

THAT MAGMA WAS MOVING UP,

IT STARTED

TO BULGE THE MOUNTAIN,

AND ONE PART OF THE MOUNTAIN CAVED AWAY,

UNCORKING A GAS-CHARGED
BODY OF MAGMA.

AND THAT GAS, ALL THOSE LITTLE BITS OF GAS HIDDEN IN THERE,

WANTED TO EXPAND ABRUPTLY,

AND THEY JUST LITERALLY

SHATTERED THE MT. ST. HELENS MAGMA BODY

AND SENT ASH ACROSS MUCH
OF THE WESTERN UNITED STATES,

CAUGHT BY THE WINDS
AND BLOWN EAST.

Argow: LAVA WAS FORCED
SO QUICKLY

INTO THE AIR
BY THE DEPRESSURIZING GASES

THAT IT SHATTERED APART

INTO BILLIONS
OF TINY PARTICLES OF ASH.

WHAT HAPPENS
WHEN THE STUFF GOES SKY-HIGH --

MOLTEN MATERIAL, ROCK, IS THROWN HIGH INTO THE ATMOSPHERE,

IT COOLS,
AND AS IT SETTLES BACK DOWN,

IT'S BASICALLY ASH,

WHICH IS LIKE A VOLCANIC SAND -- OR BIG BOMBS OR GRAVEL --

BUT IT'S NO LONGER A LIQUID, MOLTEN MATERIAL.

AND IF YOU PILE UP
THAT KIND OF MATERIAL,

YOU'RE GOING TO GET
A STEEP SIDE.

IT'S JUST LIKE IF YOU TOOK
A HANDFUL OF SAND ON THE BEACH,

AND LET IT RUN
THROUGH YOUR HAND,

YOU'RE GOING TO END UP
WITH A LITTLE MOUND.

IT'S GOING TO LOOK
LIKE A LITTLE VOLCANO MOUND.

Argow: CLASSIC STRATOVOLCANOES ARE BUILT BY EPISODIC ERUPTIONS.

THE INITIAL
VIOLENT ERUPTION OF ASH

IS FOLLOWED BY LESS-EXPLOSIVE ERUPTIONS OF LAVA

THAT COAT THE PILE
OF ASH AND DEBRIS.

THIS SEQUENCE
OF ASH AND LAVA ERUPTIONS

IS HOW STRATOVOLCANOES
ARE BUILT.

EVEN TODAY,
SMALL AMOUNTS OF LAVA

ARE STILL ERUPTING
AT MT. ST. HELENS,

AND ARE BEGINNING TO REBUILD
THE SUMMIT CONE.

BUT NOT ALL VOLCANOES
ARE BUILT IN THIS MANNER.

Sherrod: ALL OF THE HAWAIIAN ISLANDS ARE VOLCANIC,

VOLCANIC IN ORIGIN --
THEY'RE BUILT

OF ALMOST NOTHING
BUT LAVA FLOWS

STACKED ONE
ON TOP OF THE OTHER,

RISING FROM SEA-FLOOR DEPTHS
TO THE SURFACE.

IN THE CASE OF KILAUEA,

OUR 20-YEAR-OLD ERUPTION
THAT'S ONGOING NOW,

ITS EARLY DAYS

WERE HIGH FOUNTAINS,

SPECTACULAR FOUNTAINS,

AND THOSE JETS WENT AS HIGH
AS 1,400 FEET IN THE AIR.

Argow: DISSOLVED GAS
IN THE MAGMA

WAS RESPONSIBLE
FOR PROPELLING

THESE HUGE FOUNTAINS OF LAVA INTO THE AIR.

BUT THERE WAS NOT ENOUGH GAS
TO CAUSE THE EXPLOSIVE ERUPTION

AND GENERATE THE VOLUMES OF ASH THAT WE SAW AT MT. ST. HELENS.

AT KILAUEA,
ONCE THE INITIAL GAS ESCAPED,

WHAT STARTED AS A DRAMATIC, FOUNTAINING ERUPTION

TURNED INTO A MORE GENTLE, FLOWING, EFFUSIVE ERUPTION.

TODAY, LAVA SLOWLY
ADVANCES OVER THE LANDSCAPE.

AS IT HARDENS, IT CREATES
A LARGE, BROAD-SIDED VOLCANO,

KNOWN AS A SHIELD VOLCANO --

NAMED FOR ITS RESEMBLANCE
TO AN ANCIENT WARRIOR'S SHIELD.

SO ROCK DEEP IN THE EARTH
CAN MELT

UNDER THE RIGHT TEMPERATURE
AND PRESSURE CONDITIONS.

IT CAN RISE AND COLLECT
IN MAGMA CHAMBERS,

AND, WITH THE HELP OF GAS,

IT MAY EVENTUALLY ERUPT
AND BUILD A VOLCANO.

BUT, BRITT,

I'M STILL
NOT CLEAR ON WHY

THE VOLCANOES
LOOK SO DIFFERENT.

WHY DOES ONE
HAVE STEEP SIDES,

WHILE THE OTHER
SLOPES GENTLY?

WELL, JOE, IT HAS TO DO

WITH THE DIFFERENT
COMPOSITIONS OF MAGMA.

THIS IS A ROCK
THAT COOLED

FROM LAVA AT KILAUEA.

THIS IS FROM
MT. ST. HELENS.

IF WE TAKE THESE ROCKS
INTO THE LABORATORY,

WE'LL DISCOVER THAT THE ROCK

FROM MT. ST. HELENS
HAS MORE SILICA,

WHICH IS A COMBINATION OF
THE ELEMENTS SILICON AND OXYGEN.

THIS ROCK, FROM KILAUEA,

HAS A RELATIVELY LOW
SILICA CONTENT.

THE COMPOSITION IS IMPORTANT,

BECAUSE THE MORE SILICA
IN THE MAGMA,

THE MORE VISCOUS,
OR THICKER AND STICKIER,

IT WILL BE.

JOE, LET'S DO
AN EXPERIMENT.

SOUNDS GREAT.

ALL RIGHT, YOU'RE
GOING TO BE KILAUEA,

AND THIS CHOCOLATE SYRUP REPRESENTS YOUR MAGMA.

I'M GOING

TO BE MT. ST. HELENS.

AND THIS SQUEEZE MAYONNAISE REPRESENTS MY MAGMA.

SO WE'VE GOT
TWO DIFFERENT MAGMAS,

BECAUSE WE'VE
GOT VOLCANOES

WITH TWO DIFFERENT
COMPOSITIONS.

RIGHT --
NOW, LET'S ERUPT,

AND SEE WHAT KINDS
OF VOLCANOES WE BUILD.

YOUR THICKER
AND MORE VISCOUS LAVA

BUILT A HIGHER
AND STEEPER VOLCANO,

KIND OF LIKE
MT. ST. HELENS.

MINE MADE
A LOW, BROAD VOLCANO,

MORE LIKE KILAUEA.

RIGHT, THE AMOUNT
OF SILICA IN A MAGMA

DICTATES HOW VISCOUS
IT WILL BE.

AND MAGMAS HIGH IN SILICA
ALSO TEND TO CONTAIN MORE GAS.

HIGH AMOUNTS OF SILICA
AND DISSOLVED GAS

CAN LEAD TO MORE EXPLOSIVE VOLCANIC ERUPTIONS.

BRITT,
LET'S DEMONSTRATE THAT.

PASS ME THOSE BOTTLES.

ALL RIGHT.

OKAY, HERE WE'VE GOT TWO DIFFERENT TYPES OF SODAS

WITH DIFFERENT AMOUNTS

OF GAS IN THEM.

RIGHT NOW, BOTH BOTTLES
ARE UNDER PRESSURE,

AND THE GAS IS DISSOLVED --
YOU CAN'T SEE IT.

RELEASE THE PRESSURE,
AND THE VOLCANO ERUPTS.

OKAY, YOU READY?
OKAY.

ONE, TWO, THREE.

WHOA, GUESS YOU HAD
MT. ST. HELENS.

LET'S REVIEW.

VOLCANOES ERUPT
BECAUSE BUOYANT MAGMA

RISES TO THE SURFACE.

THE GASES IN MAGMA
HELP PROPEL IT

OUT OF THE EARTH'S INTERIOR,

EITHER EXPLOSIVELY

OR EFFUSIVELY,

DEPENDING UPON THE COMPOSITION

OF THE MAGMA AND THE AMOUNT

OF GAS IN THE MAGMA.

WE LEARNED ABOUT TWO TYPES
OF VOLCANOES --

EFFUSIVE SHIELD VOLCANOES,
LIKE KILAUEA IN HAWAII,

AND THE STEEP-SIDED,
EXPLOSIVE STRATOVOLCANOES,

LIKE MT. ST. HELENS.

COMPARING THE TWO DIFFERENT TYPES OF VOLCANOES

HELPS US UNDERSTAND
THE ROLE OF GASES

AND MAGMATIC COMPOSITION
IN A VOLCANIC ERUPTION.

BUT, BRITT, LET'S THINK
ABOUT WHAT MARK

AND SOME
OF THE CHILDREN TOLD US.

THEY BELIEVED
EARTHQUAKES

TRIGGERED
VOLCANIC ERUPTIONS.

YEAH,
A LOT OF ELEMENTARY

SCHOOLCHILDREN
BELIEVE THAT.

AND IT'S TRICKY, BECAUSE
IT'S NOT ENTIRELY CORRECT,

BUT IT ISN'T ENTIRELY
INCORRECT, EITHER.

FOR TWO MONTHS
BEFORE MT. ST. HELENS BLEW,

EARTHQUAKES, SWELLING GROUND, AND STEAM EXPLOSIONS

ALERTED SCIENTISTS
TO THE VOLCANO'S AWAKENING.

MOMENTS BEFORE
THE ERUPTION OCCURRED,

A LARGE EARTHQUAKE MEASURING 5.1 ON THE RICHTER SCALE

SHOOK THE GROUND.

SCIENTISTS BELIEVE
THIS IS

WHAT CAUSED
THE MASSIVE LANDSLIDE

WHICH DEPRESSURIZED
THE MAGMA

AND TRIGGERED
THE ERUPTION.

BUT WHILE EARTHQUAKES
CERTAINLY

CAN LEAD
TO VOLCANIC ERUPTIONS,

THE INVERSE ALSO OCCURS.

VOLCANIC ERUPTIONS
CAN TRIGGER EARTHQUAKES.

IF YOU REMEMBER FROM SESSION 3,
AN EARTHQUAKE OCCURS

WHEN ROCKS
INSIDE THE EARTH MOVE,

RELEASING VIBRATIONAL ENERGY.

AS MAGMA SLOWLY
RISES TO THE SURFACE,

IT PUSHES AGAINST, MELTS,

AND OFTEN BREAKS
THE SURROUNDING ROCK.

SO IN THE CASE
OF MT. ST. HELENS,

RISING MAGMA COULD HAVE TRIGGERED THE EARTHQUAKE

THAT CAUSED THE SIDE
OF THE MOUNTAIN

TO GIVE WAY,
RELEASING THE PRESSURE

AND LEADING
TO THE VIOLENT ERUPTION.

AND IT'S IMPORTANT TO NOTE
THAT AN EARTHQUAKE

CAN OCCUR
WITHOUT A VOLCANIC ERUPTION,

ESPECIALLY
AT PLATE BOUNDARIES,

WHERE ROCKS ARE JUST
SLIDING PAST EACH OTHER

WHERE THERE'S
NO MAGMA PRESENT.

BUT IT CERTAINLY SEEMS
THAT EARTHQUAKES AND VOLCANOES

TEND TO BE BEDFELLOWS.

AND THIS BECOMES
ABUNDANTLY CLEAR

WHEN WE LOOK AT A MAP
OF THE DISTRIBUTION

OF THESE SEISMIC
AND VOLCANIC PHENOMENA.

Reilly: THE GREEN DOTS
SHOW EARTHQUAKE EPICENTERS.

THE PURPLE TRIANGLES
ARE THE LOCATIONS

OF THE WORLD'S
MOST ACTIVE VOLCANOES.

DO YOU SEE A PATTERN HERE?

MOST FALL ON PLATE BOUNDARIES,

AND MANY OF THE MOST GEOLOGICALLY ACTIVE AREAS

IN THE WORLD ARE LOCATED
AROUND THE PACIFIC OCEAN.

IF WE START

AT THE SOUTHERNMOST TIP
OF SOUTH AMERICA

AND FOLLOW THE PLATE BOUNDARIES, WE SEE THE ANDES,

A CHAIN OF VOLCANIC MOUNTAINS

WHICH INCLUDES GALERAS VOLCANO IN COLOMBIA.

UP THROUGH CENTRAL AMERICA
TO THE CASCADE MOUNTAIN RANGE,

WHICH INCLUDES MT. ST. HELENS.

PAST ALASKA,

WE SEE THE ALEUTIAN
VOLCANIC ISLAND ARC.

THEN DOWN THROUGH THE VOLCANOES IN RUSSIA, UNTIL WE REACH JAPAN,

WITH ITS FAMOUS MOUNT FUJI.

IN THE PHILIPPINES,
THERE IS MOUNT PINATUBO,

AND IN INDONESIA,

THERE'S KRAKATOA.

THESE ARE JUST A HANDFUL
OF THE VOLCANOES

AROUND WHAT SCIENTISTS CALL
"THE RING OF FIRE."

AND THE MAJORITY
OF THESE VOLCANOES

ARE STEEP-SIDED
STRATOVOLCANOES.

SO WHAT'S GOING ON
AT THE PLATE BOUNDARIES

TO PRODUCE THIS SO-CALLED
"RING OF FIRE"?

THAT'S EXACTLY WHAT SIXTH-GRADERS

AT FOOTHILLS MIDDLE SCHOOL

IN WALNUT CREEK, CALIFORNIA

ARE TRYING TO FIGURE OUT.

SO YOU CLICKED WHERE?

Reilly: TODAY, ARIEL OWEN
IS LEADING HER STUDENTS

THROUGH THE WISE, OR WEB-BASED INQUIRY SCIENCE ENVIRONMENT,

CURRICULUM.

OKAY, SO,
THE IMPORTANT FEATURES

THAT ARE INCLUDED ARE --
SO WHAT DID YOU SEE?

Reilly: HER STUDENTS ARE USING MAPS OF GEOLOGIC ACTIVITY

TO EXPLORE THEIR CONCEPTUAL MODELS OF FACTORS

THAT SET EARTHQUAKES
AND VOLCANOES IN MOTION.

"EXPLORE THE FOUR TYPES
OF BOUNDARIES.

"TRANSFORM BOUNDARIES,
DIVERGENT BOUNDARIES,

"COLLISIONAL BOUNDARIES,

AND CONVERGENT BOUNDARIES.

"PAY VERY CLOSE ATTENTION
TO WHAT HAPPENS

TO THE EARTH'S CRUST
AT EACH TYPE OF BOUNDARY."

IT'S LIKE
A LITTLE TRAIL --

WHEREVER YOU SEE
A PLATE CRACK,

THERE'S A EARTHQUAKE,
AND THERE,

NEARBY, IS A VOLCANO.

BASICALLY,
NO VOLCANOES ARE NOT

ON A PLATE BOUNDARY
OR NEAR AN EARTHQUAKE.

OKAY, DOES THAT
MAKES SENSE?

Owen: WHEN STUDENTS ARE TALKING ABOUT PLATE TECTONICS,

THIS IS NOT AN IDEA -- FIRST OF ALL, IT'S A VERY NEW THEORY.

SECONDLY,
IT'S NOT SOMETHING

WHERE WE CAN
GO INSIDE OF THE EARTH

AND SAY, "SEE, LOOK,
SEE IT MOVING?"

THEY CAN'T SEE THAT --

AND OUR STUDENTS
ARE VERY VISUAL.

THEY'RE USED TO SEEING THINGS, WHETHER IT'S A GAME,

WHETHER IT'S TV,
WHETHER IT'S A MOVIE.

SO HAVING THESE SIMULATIONS AVAILABLE TO THEM

IS A VERY POWERFUL TOOL
TO HELP THEM COME TO GRIPS

WITH A REALLY ESOTERIC IDEA OF, "NORTH AMERICA MOVES,

"AND SO DOES THE PACIFIC OCEAN,
AND SO DOES SOUTH AMERICA,

AND AFRICA AND SOUTH AMERICA USED TO BE NEIGHBORS."

SEE, WHEN YOU LOOK
AT THIS PICTURE,

THIS TECTONIC PLATE,
RIGHT?

WAIT, WHICH ONES
ARE THE PLATES?

THE BLUE LINE
IS THE PLATE BOUNDARY.

SO HERE, WHAT DO YOU NOTICE ABOUT THE BLUE LINES?

THEY'RE ALL
ALONG THE WEST COAST

OF THE UNITED STATES --

SO THAT'S THE ONLY PLACE
YOU SEE

BLUE LINES
IS ALONG THE WEST COAST?

AND THEN THEY GO
RIGHT DOWN --

SO THESE ARE ALL
PLATE BOUNDARIES,

AND WHAT DO YOU NOTICE
HAPPENS ALONG THOSE PLATES?

THERE'S A TON OF EARTHQUAKES RIGHT ALONG THEM.

OKAY, SO WHAT
I'M SAYING HERE

IS I DON'T SEE
ANYTHING IN THIS NOTE

ABOUT
THE PLATE BOUNDARIES.

SO, "THERE ARE
MANY EARTHQUAKES

"WHERE THE VOLCANOES
ARE ACTIVE IN THE U.S.

WHERE THERE
ARE VERY FEW..."

THAT'S GOOD, BUT NOW,
WHAT ABOUT THE LOCATION --

OH, SO --
CAN YOU GIVE ME A LITTLE
BIT MORE INFORMATION THERE?

SO WE WRITE,
"VOLCANOES AND EARTHQUAKES

ALONG THE PLATES'
BOUNDARIES"?

YEAH, THAT MAKES MORE
SENSE TO ME, SO GO BACK

INTO YOUR NOTE AND GIVE ME
A LITTLE BIT MORE DETAIL.

AND THEN I WANT YOU
TO DOUBLE-CHECK

YOUR OTHER NOTES
FOR THAT.

I THINK YOU'RE GOING
A LITTLE SPEEDY.
OKAY.

YOU THINK?
YEAH, I SEE.

NO RUSH, GUYS,
WE'VE GOT LOTS OF TIME.

"THERE ARE LOTS
OF VOLCANOES --"

"THERE ARE A LOT --"

I KNOW.

"ARE MANY EARTHQUAKES
AND VOLCANOES

ALONG THE PLATE'S BOUNDARY."

"YOU SHOULD THINK ABOUT HOW
PLATE BOUNDARIES ARE IMPORTANT

"IN DESCRIBING THE DIFFERENCES BETWEEN THE GEOLOGY

ON YOUR COAST
AND THE OPPOSITE ONE."

SO THE RELATION
BETWEEN THE LOCATION

OF THE PLATE BOUNDARIES
AND THE LOCATION

OF THE VOLCANOES
AND EARTHQUAKES IS THAT...

Owen: WELL, THE STANDARDS
THAT WE'RE PRESENTED WITH

TELL US THAT THE CHILDREN
NEED TO LEARN ABOUT CONSTRUCTIVE

AND DESTRUCTIVE FORCES,

CERTAINLY IN CALIFORNIA,
WITH THE EARTHQUAKES

AND GEOLOGY OF THIS AREA,
IT'S VERY RICH.

FURTHER,
THE STANDARDS SAY

THAT THEY HAVE TO HAVE
AN UNDERSTANDING

OF THE INTERNAL WORKINGS
OF THE PLANET.

SO PLATE TECTONICS,
ALTHOUGH IT'S

A RELATIVELY NEW THEORY,
FITS INTO THAT VERY NICELY.

YOU'VE GOT
YOUR CONSTRUCTIVE FORCES

IN THE DEVELOPMENT
OF THE HAWAIIAN ISLANDS,

YOU'VE GOT YOUR DESTRUCTIVE FORCES IN THE LOSS OF LAND

DUE TO EARTHQUAKES
AND EROSION, SO.

OKAY, WELL, BASICALLY,
WHEREVER THE PLATES ARE --

SO IF THIS IS A PLATE --
IT'S LIKE A CHAIN.

LIKE, THIS IS

LIKE THE CRACK,

AND RIGHT HERE ARE ALL
THE LITTLE EARTHQUAKES.

AND OVER HERE,
WHERE LIKE THE TEXTBOOK IS,

IS LIKE WHERE ALL
THE BIG VOLCANOES ARE.

BECAUSE LIKE,
THE SAN ANDREAS FAULT IS LIKE

KIND OF LOCATED
REALLY CLOSE TO A PLATE LINE,

AND IT'S NOT TOTALLY
CONNECTED TO ANYTHING,

IT'S ONLY
CONNECTED TO --

YEAH, IT'S JUST BASICALLY
WHERE THE PLATES ARE,

VOLCANOES AND EARTHQUAKES
ARE LIKE A SURE-FIRE THING.
RIGHT.

SO WHEN EVERYONE
COMES OVER

FROM THE EAST COAST
TO OUR PLACE --
YEAH!

AND THEY'RE
ALL LIKE, DANG,

THAT'S A LOT
OF EARTHQUAKES!
YEAH!

Reilly: IN OUR LIFETIME,
SEVERAL ENORMOUS EARTHQUAKES

HAVE ROCKED CALIFORNIA,
LEAVING BEHIND A TRAIL

OF DEVASTATION.

IT'S BECAUSE THIS AREA IS FULL OF HUGE CRACKS IN THE CRUST

CALLED FAULTS.

THESE FAULTS,

LIKE THE SAN ANDREAS FAULT,

MARK THE BOUNDARY BETWEEN
THE NORTH AMERICAN PLATE

AND THE PACIFIC PLATE.

THE SAN ANDREAS FAULT IS KNOWN AS A STRIKE-SLIP FAULT,

WHERE THE PLATES SLIDE HORIZONTALLY PAST ONE ANOTHER.

FRICTION OCCURS,
CAUSING THE EARTHQUAKES.

AND THERE'S ALWAYS
THE CONCEPT OF,

WELL, IS CALIFORNIA GOING
TO FALL OFF INTO THE OCEAN?

IS THE WEST SIDE ON THE WEST SIDE OF THE SAN ANDREAS FAULT

GOING TO EVENTUALLY JUST GO PLOP AND FALL INTO THE OCEAN?

WELL, THAT'S KIND OF A FANTASY.

MOST GEOLOGISTS DON'T BELIEVE THAT IT WILL FALL OFF,

BUT THEY DO KNOW
THAT IT WILL CONTINUE

TO BE A VERY ACTIVE PLACE.

SO WHAT'S UNIQUE
ABOUT THE SAN ANDREAS FAULT?

WELL, HERE'S A PLACE

WHERE THE CONTINENTS
ARE MOVING SIDEWAYS,

SO NOW WE HAVE A RIP SYSTEM;

THEY'RE MOVING
ALONG EACH OTHER.

BUT THERE'S NO BIG GAP THERE -- I MEAN,

YOU'VE GOT TREMENDOUS PRESSURE IN THE EARTH

HOLDING IT TOGETHER
AS IT'S TRYING TO MOVE

IN RELATIONSHIP TO EACH OTHER.

SO WHAT HAPPENS IS IT MOVES,
BUT DOESN'T IT MOVE SMOOTHLY.

THAT'S THE PROBLEM;
IT'S NOT SMOOTH.

SO AS IT MOVES,
TREMENDOUS PRESSURE BUILDS UP

ON THE OCEAN SIDE,
AND IT SLIPS, LIKE THIS.

AND THEN IT'LL SLIP AGAIN.

EVERY TIME IT SLIPS,
THERE'S A LOT OF FRICTION,

THERE'S A LOT OF VIBRATION
PUT OUT,

AND WE CREATE WHAT WE KNOW
AS THE BIG EARTHQUAKE.

Reilly: THIS TYPE
OF PLATE INTERACTION

PRODUCES MANY POWERFUL
AND DEVASTATING EARTHQUAKES.

BUT VIOLENT EARTHQUAKES
ALSO OCCUR

AT OTHER TYPES
OF PLATE BOUNDARIES --

SPECIFICALLY, WHERE PLATES
ARE COLLIDING INTO ONE ANOTHER.

BUT IS IT A COINCIDENCE
THAT PLATE BOUNDARIES ARE ALSO

WHERE WE FIND EARTHQUAKES' GEOLOGIC COUSINS, VOLCANOES?

MT. ST. HELENS, FOR INSTANCE,

IS LOCATED ALONG THIS
COLLIDING PLATE BOUNDARY.

MT. FUJI IS LOCATED
AT THIS COLLIDING BOUNDARY.

KRAKATOA, AT THIS ONE.

WHY ARE ALL OF THE VOLCANOES THAT MAKE UP "THE RING OF FIRE"

LOCATED WHERE TWO PLATES
ARE COLLIDING?

IN OTHER WORDS,

WHAT EXACTLY IS HAPPENING

AT COLLIDING PLATE BOUNDARIES THAT CAUSE VOLCANOES TO ERUPT?

Argow: IF YOU REMEMBER
EARLIER IN THE SESSION,

MARK HAD AN IDEA
ABOUT EARTHQUAKES

CAUSING VOLCANIC ERUPTIONS.

BUT MARK ALSO BELIEVES
THAT WHEN TWO PLATES COLLIDE,

ONE PLATE GOES UNDER THE OTHER, CAUSING A VOLCANO TO ERUPT.

Interviewer:
WHAT AM I LOOKING AT HERE?

YOU SAID ONE PLATE GOES UNDERNEATH THE OTHER?

YES.

WHAT'S THAT ALL ABOUT?

THAT'S BECAUSE
IT CRASHES,

AND THE SMALLER PLATE
GOES UNDERNEATH,

BECAUSE IT'S
SMALLER AND WEAKER.

ALL RIGHT, MARK, WHAT IF
THOSE WERE THE PLATES?

IF THOSE
WERE THE PLATES...

YOU DON'T HAVE
TO USE ALL THREE.

I'M JUST GOING TO USE
THIS ONE AND --

OH, WHAT ABOUT
THIS ONE AND THIS ONE?

OKAY.
OKAY.

THE SMALLER PLATE

EVENTUALLY
WILL MOVE UNDER.

WHY?

BECAUSE THE BIGGER PLATE
HAS MORE FORCE,

AND IT'S PUSHING THEM UNDERNEATH.

PUSHING IT,
BUT IT'S PUSHING, AS WELL,

SO THE ONLY CHANCE
OF EITHER OF THEM MOVING

IS IF THE SMALLER ONE
GOES UNDER.

THEN THAT GOES
INTO THE MANTLE,

AND MELTS.

WELL, CAN I SEE
THAT CANISTER OF GLUE NOW?

ABSOLUTELY.

HOW ABOUT, THIS IS
THE MANTLE, THIS PLATFORM?

OKAY.

AND MY HANDS
ARE THE PLATES,

AND WHEN MY HANDS
ARE MOVING,

THEY'RE, THEY'RE MOVING

BECAUSE OF THE MANTLE
PUSHING THEM.

AND THIS IS THE VOLCANO.

Argow: MARK BELIEVES THAT ONE PLATE GOES UNDER ANOTHER PLATE,

AND WHEN THESE PLATES COLLIDE,

THEY SQUEEZE TOGETHER
AND PUSH LAVA OUT OF A VOLCANO,

LIKE GLUE BEING SQUEEZED
OUT OF ITS CONTAINER.

DO YOU AGREE WITH MARK?

CAN ONE PLATE
GO UNDERNEATH ANOTHER?

LET'S EXAMINE THESE TWO ROCKS.

THIS ONE CAME
FROM THE SEA FLOOR.

IT'S CALLED BASALT.

THIS IS A TYPICAL
CONTINENTAL ROCK

THAT MANY PEOPLE
HAVE HEARD OF.

IT'S A GRANITE.

NOW, IMAGINE THAT THIS
IS AN OCEANIC PLATE,

AND THIS GRANITE
IS A CONTINENTAL PLATE,

AND THAT THEY'RE COLLIDING.

WHAT'S GOING TO HAPPEN?

WELL, FIRST OF ALL,
THE GRANITIC CONTINENTAL PLATE

IS MUCH, MUCH THICKER --
ON AVERAGE, 40 KILOMETERS THICK.

THE BASALTIC OCEANIC PLATE
IS MUCH THINNER --

ONLY ABOUT
8 TO 10 KILOMETERS THICK.

SO YOU'VE GOT
A REALLY THICK PLATE

COLLIDING
WITH A THINNER PLATE.

AND ON TOP OF THAT, BASALT HAS MORE IRON AND MAGNESIUM IN IT,

MAKING IT MUCH MORE DENSE
THAN GRANITE.

SO WHAT'S GOING TO HAPPEN

WHEN A THIN, DENSE PLATE
HITS A THICK, BUOYANT PLATE?

THE THIN, DENSE PLATE

IS GOING TO GO DOWN.

THIS IS CALLED SUBDUCTION.

IF ONE PLATE
IS MOVING IN ONE DIRECTION,

AND THE OTHER ONE IS EITHER MOVING IN THE OPPOSITE DIRECTION

OR ONE IS STATIONARY,
THEY'RE GOING TO COLLIDE.

AND WHEN AN OCEAN BASIN COLLIDES WITH A CONTINENT,

BECAUSE THE OCEAN IS DENSER -- BASALT IS DENSER THAN GRANITE --

IT WILL SLIP UNDERNEATH.

THAT'S CALLED SUBDUCTION.

THESE ARE CALLED
SUBDUCTION ZONES.

AND IF YOU LOOK AT
THE TOPOGRAPHY

OF THE OCEAN BASINS,
YOU WILL SEE

BIG GASHES,
CALLED TRENCHES,

WHERE THE SEA FLOOR
IS DRAGGED DOWN

ALONG THOSE LOCATIONS.

Argow: THESE TRENCHES
CAN BE MILES DEEP,

AND ARE OFTEN FOUND WHERE ONE PLATE IS MOVING UNDER ANOTHER.

FOR EXAMPLE, LARGE SECTIONS
OF THE OCEANIC PACIFIC PLATE

ARE MOVING BACK INTO
THE INTERIOR OF THE EARTH

IN THESE LOCATIONS,
WHERE THE PACIFIC PLATE

IS COLLIDING
WITH CONTINENTAL CRUST.

OKAY, JOE, LET'S IMAGINE
THAT THIS TANK

IS A SMALL SLICE
OF THE OUTERMOST PART

OF THE EARTH'S
INTERIOR.

NOW, THE JELLY HERE
REPRESENTS THE ASTHENOSPHERE,

THE FLOWING SOLID LAYER
ON WHICH THE PLATES MOVE.

THIS SPONGE HERE REPRESENTS CONTINENTAL PLATE.

AND THIS REPRESENTS
AN OCEANIC PLATE.

AS THE TWO PLATES COLLIDE,

THE THINNER PLATE
IS GOING

TO SUBDUCT
UNDER THE THICKER PLATE

AND DIVE
INTO THE MANTLE.

AS THE ROCKS COLLIDE

AND RUB AGAINST EACH OTHER,
ENERGY IS RELEASED

IN THE FORM OF EARTHQUAKES
IN BOTH PLATES.

BRITT, I CAN UNDERSTAND WHY EARTHQUAKES OCCUR HERE,

BUT WHY ARE THERE VOLCANOES
AT SUBDUCTION ZONES?

IS THE MAGMA LITERALLY
BEING SQUEEZED

OUT OF THE GROUND,
LIKE MARK SUGGESTED?

WHILE MARK HAS SOME SOPHISTICATED IDEAS

ABOUT SUBDUCTION,
SCIENTISTS DO NOT BELIEVE

THAT THIS IS THE REASON

WHY VOLCANOES ERUPT
AT SUBDUCTION ZONES.

IN ORDER TO UNDERSTAND THESE TYPES OF VOLCANIC ERUPTIONS,

WE NEED TO KNOW HOW AND WHY

THE ROCK IS MELTING
TO CREATE THESE VOLCANOES.

WE LEARNED EARLIER

THAT TEMPERATURE AND PRESSURE
CONTROL MELTING.

BUT IT TURNS OUT
THAT THERE IS

ANOTHER VARIABLE
IN THE MELTING PROCESS.

JOE, AS THIS
OCEANIC PLATE SUBDUCTS

DOWN UNDERNEATH THE OVERLYING CONTINENTAL PLATE,

WATER AND SOME SEDIMENT

THAT'S ON TOP
OF THE OCEANIC PLATE

IS SUBDUCTING DOWN,
AS WELL.

AND SCIENTISTS HAVE LEARNED
THAT THE PRESENCE OF WATER

LOWERS THE TEMPERATURE
AT WHICH ROCK CAN MELT.

AT SUBDUCTION ZONES,
THE KEY FACTOR

TRIGGERING THE MELTING OF ROCK IS WATER.

AND YOU MIGHT SAY,
"WELL, WHY WOULD YOU MELT,

JUST BECAUSE YOU TAKE
OCEANIC CRUST DOWN?"

AND IT TURNS OUT
THAT OCEANIC CRUST

BECOMES HYDRATED;
IT'S RICH IN WATER.

YOU'RE DRAGGING COOL,
WATER-RICH CRUST

INTO THE EARTH'S DEPTHS,
WHERE IT HEATS.

WATER IS A PRETTY GOOD AGENT
TO PROMOTE MELTING.

SO AS THIS STUFF GOES DOWN,

IT GETS TO A TEMPERATURE
AND PRESSURE

WHERE MELTING IS FAVORED.

AND THAT PARTIALLY
MOLTEN ROCK

WILL, BECAUSE IT'S
LESS DENSE, IT'S HOT,

WANTS TO RISE,
JUST LIKE GAS BUBBLES

IN A BOILING POT OF WATER,

IT'S GOING TO RISE
TOWARDS THE SURFACE,

AND WHEN IT TOUCHES THE SURFACE, IT FORMS A VOLCANO.

Argow: AT SUBDUCTION ZONES,
THE OCEANIC PLATE

IS FORCED DOWN
UNDER THE OVERRIDING PLATE.

THE OCEANIC CRUST HAS MINERALS THAT CONTAIN WATER,

AND IT'S ALSO CARRYING
A LAYER OF SEDIMENT

RICH IN CARBON DIOXIDE.

AS THE PLATE SUBDUCTS,
WATER AND CARBON DIOXIDE

ARE RELEASED
FROM THE ROCKS AND SEDIMENTS.

THIS HELPS TO LOWER
THE MELTING POINT

OF THE MANTLE
UNDER THE CONTINENTAL PLATE.

SO THE MANTLE BEGINS TO MELT.

THE RESULT IS A THICK,

BUOYANT MASS OF MAGMA,

SUPER-CHARGED WITH GASES LIKE WATER VAPOR AND CARBON DIOXIDE.

AS THE HOT MELT RISES,
IT CONSUMES SOME

OF THE SILICA-RICH
CONTINENTAL CRUST.

IT WILL ERUPT EXPLOSIVELY,

CREATING STRATOVOLCANOES,
LIKE MT. ST. HELENS.

THIS IS WHY
EXPLOSIVE VOLCANISM

IS OFTEN ASSOCIATED
WITH SUBDUCTION ZONES.

Reilly: LET'S REVIEW.

EARTHQUAKES OCCUR WHEN ROCK INSIDE THE EARTH MOVES

AND RELEASES VIBRATIONAL ENERGY.

EARTHQUAKES CAN BE TRIGGERED
BY RISING MAGMA,

OR MORE COMMONLY,
WHEN PLATES INTERACT.

WHEN OCEANIC AND CONTINENTAL
PLATES COLLIDE,

OCEANIC PLATE SUBDUCTS.

THIS PLATE INTERACTION
CREATES EARTHQUAKES,

AND IT ALSO GENERATES MAGMA, WHICH CAN ERUPT AS VOLCANOES.

MOST SUBDUCTION-ZONE VOLCANOES ARE STEEP-SIDED AND EXPLOSIVE.

SO, BRITT,
ALL ALONG THIS "RING OF FIRE,"

WE'VE GOT THESE HUGE TRENCHES WHERE OCEANIC CRUST

IS SUBDUCTING UNDERNEATH
CONTINENTAL CRUST.

AT SOME POINT,
WILL THE ENTIRE PLATE

GET PULLED DOWN

INSIDE THE EARTH?

WELL, AS LONG AS THE PLATES CONTINUE TO COLLIDE,

THE OCEANIC PLATE
WILL CONTINUE TO SUBDUCT.

WELL, DOES THAT MEAN
THE EARTH IS SHRINKING?

NO, THE EARTH
IS NOT SHRINKING,

BECAUSE AS ONE PART OF
THE PLATE IS BEING SUBDUCTED,

SOMEWHERE ELSE,
OCEANIC PLATE IS BEING CREATED.

LET'S LOOK
AT THE PACIFIC PLATE.

NOW, THIS PLATE IS ENTIRELY
MADE UP OF DENSE, OCEANIC ROCK,

AND IT'S MOVING IN
A NORTHWESTERLY DIRECTION.

SO THE PLATE
IS SUBDUCTING

HERE,
ALONG THIS BOUNDARY.

BUT IF WE LOOK AT THE OTHER
SIDE OF THE PACIFIC PLATE,

WE SEE A HUGE UNDERWATER MOUNTAIN RANGE.

NOW, THIS MOUNTAIN RANGE

IS MADE OF NEARLY
CONTINUOUS VOLCANOES,

AND IT'S CALLED
A SPREADING RIDGE.

WHILE SUBDUCTION ZONES
PULL THE OCEANIC PLATES DOWN,

AT SPREADING RIDGES,
MAGMA IS RISING

AND FILLING IN THE GAPS
WITH NEW CRUST.

AT THESE GAPS, SCIENTISTS THEORIZE THAT THE RISING MAGMA

MAY ALSO PUSH THE PLATES ASIDE.

Sherrod:
WHAT'S HAPPENING THERE IS,

AS THE PLATES PULL APART,
MANTLE,

SHALLOW MANTLE
BENEATH THE OCEANIC CRUST,

COMES UP
AND ADDS NEW PLATE MATERIAL

IN THE FORM OF LAVA FLOWS.

SO THE MOST ACTIVE VOLCANOES
IN THE WORLD

ARE ALL UNDER THE OCEAN.

THEY'RE ALL LOCATED ALONG
THE BOUNDARIES BETWEEN PLATES,

BUT THIS TIME, IT'S A PLATE THAT'S SPREADING APART,

AND IT'S JUST LIKE UNZIPPERING ONE LONG MAGMATIC CHAIN,

ONE LONG VOLCANIC SYSTEM.

IT'S A LITTLE BIT LIKE
A BIG WOUND ON YOUR ARM.

LIKE IF YOU HAD A CUT,

AND IT KEEPS SPREADING APART
AND OOZING.

SOMETHING'S FILLING IN
BEHIND THAT.

THAT'S WHAT HAPPENS AS
THE OCEAN BASINS SPREAD APART.

LAVA COMES UP FROM UNDERNEATH AND REPLACES THAT

WITH VOLCANIC MATERIAL
THAT MAKES UP THE OCEAN BASIN,

THE VOLCANIC MATERIAL
FROM THE MANTLE

IS REPLACING
MATERIAL THAT'S IN THAT SPACE.

Argow:

THESE MID-OCEAN RIDGES

CIRCLE THE EARTH
LIKE SEAMS ON A BASEBALL.

BUT HOW DO WE KNOW
THAT OCEANIC PLATES

ARE REALLY BEING CREATED
AT THESE RIDGES?

NEAR THE RIDGES,
RADIOACTIVE DATING SHOWS

THAT THE CRUST
IS QUITE YOUNG.

THE FARTHER AWAY YOU MOVE
FROM THE SPREADING CENTER,

THE OLDER THE CRUST GETS.

THIS IS WHAT YOU WOULD EXPECT
TO OBSERVE IF THE PLATES

WERE CREATED AT THE RIDGE,
AND THEN MOVED APART OVER TIME.

Reilly: SCIENTISTS BELIEVE
THAT IN THE DISTANT PAST,

SOUTH AMERICA AND AFRICA
USED TO BE JOINED.

A RIFT DEVELOPED,
SEPARATING THE TWO CONTINENTS.

THIS RIFT BECAME

THE MID-ATLANTIC
SPREADING RIDGE.

AS THE PLATES MOVED APART,
NEW CRUST WAS GENERATED.

AFTER HUNDREDS
OF MILLIONS OF YEARS,

THE ATLANTIC OCEAN BASIN GREW
TO THE SIZE WE KNOW TODAY,

COMPLETELY SEPARATING
SOUTH AMERICA AND AFRICA.

IF WE LOOK AGAIN
AT THE PACIFIC PLATE,

WE SEE THE PACIFIC
SPREADING RIDGE.

HERE, MAGMA
THAT RISES TO THE SURFACE

HARDENS
AND TREKS ACROSS THE GLOBE

UNTIL IT FINALLY SUBDUCTS
BACK INTO THE MANTLE

UNDER PLACES
LIKE JAPAN AND ALASKA.

IT'S LIKE A HUGE CONVEYOR BELT
CREATING, TRANSPORTING,

AND FINALLY RECYCLING ROCK.

SCIENTISTS ESTIMATE
THE JOURNEY ACROSS THE PACIFIC

TAKES CLOSE
TO 200 MILLION YEARS.

IS THAT A LONG TIME?

IT IS, BUT IT'S NOT AS LONG
AS THE EARTH HAS BEEN AROUND,

BECAUSE WE KNOW THE EARTH IS

ON THE ORDER OF
4.5 BILLION YEARS OLD.

THE CONTINENTS,
WHICH ARE KIND OF FLOATING

UP ABOVE ALL THIS STUFF,

ARE VERY OLD, BUT THE OCEAN BASINS THEMSELVES

HAVE BEEN COMPLETELY RECYCLED MANY, MANY, MANY TIMES.

YOU CAN'T FIND
OCEAN BASIN THAT'S OLDER

THAN ABOUT
180 TO 200 MILLION YEARS,

BECAUSE THE OCEAN BASIN
IS BEING CREATED, MOVES,

AND BEING REABSORBED,
IN A HUGE CYCLE OF --

WELL, IT'S MAYBE
THE FIRST CONCEPT

OF RECYCLING ON THE PLANET.

THE EARTH FIGURED THAT OUT BEFORE HUMANS DID.

BUT YOU'VE GOT THIS COMPLETE RECYCLING OF THE OCEAN BASINS.

SO WE HAVE A PLANET-SIZED RECYCLING SYSTEM

CONTINUOUSLY SUBDUCTING
OCEANIC PLATES

BACK INTO
THE EARTH'S INTERIOR.

BUT DON'T WORRY, THE LAND

ON WHICH MOST OF US LIVE,
THE CONTINENTS,

ARE UNLIKELY TO SUBDUCT, BECAUSE ONLY OCEANIC CRUST IS RECYCLED.

SUBDUCTION IS WHY THE OLDEST OCEANIC CRUST ON EARTH

IS ONLY ABOUT
200 MILLION YEARS OLD.

IN CONTRAST, THE OLDEST CONTINENTAL CRUST

IS CLOSE TO
4 BILLION YEARS OLD.

BECAUSE CONTINENTAL CRUST
IS LESS DENSE,

IT WILL STAY AT THE SURFACE INDEFINITELY.

BUT NOT EVERYTHING
WE CALL "LAND"

IS MADE
OF CONTINENTAL CRUST.

THE HAWAIIAN ISLANDS
ARE IN THE MIDDLE

OF THE OCEANIC
PACIFIC PLATE,

AND THEY'RE MADE
OF BASALT,

THE SAME TYPE OF ROCK
THAT MAKES UP OCEANIC CRUST.

SO EVENTUALLY,
HAWAII COULD BE

RECYCLED
AT A SUBDUCTION ZONE.

JOE, TODAY SCIENTISTS
BELIEVE THAT SUBDUCTION

IS A MAJOR MECHANISM
THAT DRIVES PLATE TECTONICS.

SEA FLOOR SPREADING
AND THE UPWELLING OF MAGMA

PLAY A VERY IMPORTANT ROLE,
AS WELL.

BRITT, WE LEARNED
THAT THE PLATE BOUNDARIES

ARE A HOTBED
OF SEISMIC ACTIVITY --

THIS WHOLE AREA
AROUND HERE.

BUT HAWAII IS SMACK-DAB
IN THE MIDDLE OF THE PLATE,

AND IT EXPERIENCES LOADS

OF VOLCANIC
AND SEISMIC ACTIVITY.

WHAT'S GOING ON?

WHY ARE THERE VOLCANOES
IN THE MIDDLE OF A PLATE?

I THINK IT'S TIME
TO HEAD BACK TO HAWAII

AND INVESTIGATE
THE MYSTERY WE INTRODUCED

AT THE BEGINNING
OF THE SESSION.

IF YOU REMEMBER, VOLCANOES ON SEVEN OUT OF THE EIGHT ISLANDS

NO LONGER ERUPT.

ONCE WE UNDERSTAND WHAT HAPPENED TO THESE VOLCANOES,

WE'LL KNOW WHY HAWAII
IS SO DIFFERENT

FROM SUBDUCTION-ZONE VOLCANOES
LIKE MT. ST. HELENS.

Sherrod: ALL THESE ISLANDS,
THE EIGHT MAJOR ISLANDS,

ALL OF THEM ARE VOLCANIC;

THEY ALL GREW
BY VOLCANIC ERUPTIONS.

WE KNOW THIS BECAUSE THEY'RE BUILT OF LAVA FLOWS.

THE SAME KIND OF ROCKS
I'M SITTING ON TODAY

ARE FOUND IN KAUAI,
THEY'RE FOUND ON OAHU,

THEY UNDERLIE
OUR CAPITAL CITY, HONOLULU.

AND YET NONE OF THEM
ARE ERUPTING

EXCEPT THE BIG ISLAND
AND ITS VOLCANO, KILAUEA.

THAT LEADS US TO THE QUESTION,

WHY DID THOSE VOLCANOES
GO EXTINCT?

WHAT'S THIS ONE
GOT GOING FOR IT

THAT THOSE OTHERS MAY ONCE
HAVE HAD, BUT HAVE LOST?

I LIKE -- I GUESS
IF I WERE THE DOCTOR

WANTING TO PUT MY STETHOSCOPE
ON THIS PATIENT,

I'D USE THE STETHOSCOPE
OF SEISMICITY.

I'D ASK ABOUT EARTHQUAKES.

AND THE REASON I DO THAT
IS BECAUSE THAT'S A GOOD WAY

TO SEE DEEP INTO THE EARTH'S CRUST AND MANTLE.

WHEN YOU GET

RIGHT DOWN TO IT,

WHEN MAGMA MOVES UP THROUGH
THE CRUST, IT BREAKS ROCK.

AND WHENEVER YOU BREAK ROCK,
YOU GET EARTHQUAKES.

NOW, WE'VE MONITORED
THIS VOLCANO ON THE BIG ISLAND

WITH PROBABLY
OVER 150 SEISMOMETERS,

AND WE'RE ABLE TO TRACK
THE DEPTHS

AT WHICH EARTHQUAKES OCCUR,

AND IN SOME CASES EVEN MONITOR THE UPWARD RISE OF MAGMA,

BY THE TELLTALE SNAPPING
OF THE EARTH'S ROCKS

AS THE MAGMA COMES
TO THE SURFACE.

Argow:
ON THE ISLAND OF HAWAII,

WHERE THERE IS
ACTIVE VOLCANISM,

THERE ARE EARTHQUAKES.

BUT WHERE NO VOLCANOES
ARE ERUPTING,

EARTHQUAKES
ARE RELATIVELY RARE --

LIKE 350 MILES NORTHWEST
OF THE BIG ISLAND,

ON THE ISLAND OF KAUAI.

Sherrod: IF YOU'RE LOOKING
FOR EARTHQUAKES IN HAWAII,

YOU DON'T COME TO KAUAI.

IT'S A VERY QUIET,
STABLE ISLAND,

ALMOST NO EARTHQUAKES HERE.

IF YOU'RE LOOKING FOR ACTIVE VOLCANOES IN HAWAII,

YOU DON'T COME TO KAUAI.

KAUAI IS DEAD, VOLCANICALLY.

WE HAVE NOT HAD
ANY OBVIOUS ERUPTIONS

THAT WE COULD INTERPRET
AS BEING RELATIVELY YOUNG

FOR A VERY LONG TIME.

Argow: DATING THE ROCKS
ON THE ISLAND HAS REVEALED

THAT KAUAI IS BETWEEN
4 AND 6 MILLION YEARS OLD.

AS WE MOVE SOUTHEAST
ALONG THE CHAIN,

THE ISLANDS
GET PROGRESSIVELY YOUNGER,

UNTIL WE GET
TO THE BIG ISLAND,

WHERE MAGMA IS STILL
REACHING THE SURFACE TODAY.

THE OLDEST PART
OF THE BIG ISLAND

IS ONLY ABOUT
ONE MILLION YEARS OLD.

Sherrod: IT SUGGESTS
THAT EARTHQUAKES, HEAT FLOW,

AND MAGMATISM ARE ALL RELATED,

AND THAT WHATEVER
THAT PHENOMENON IS,

IT HAS GONE EXTINCT,
IT HAS GONE OUT,

IT'S BEEN SNUFFED,
IT'S DIED AWAY,

AT THE OTHER ISLANDS
IN THE VOLCANIC CHAIN.

WHATEVER IS DRIVING THE SHOW
AIN'T THERE; IT'S HERE.

THIS IS THE PLACE TO BE.

WHY --
I GUESS THAT'S THE QUESTION

WE'VE GOT TO COME DOWN TO.

WHAT HAS KEPT MAGMA
FROM GETTING

TO THE VOLCANOES
IN THE OTHER ISLANDS?

WHY ARE THEY STARVED?

WHY DID THE HEAT GO AWAY?

ONE POSSIBLE EXPLANATION
WOULD BE

THAT THE SOURCE OF LAVA
THAT CREATED KAUAI

HAS MOVED TO WHERE
THE BIG ISLAND IS NOW.

AT ONE TIME, IT WAS HERE;
NOW IT'S HERE.

OR MAYBE THERE WERE
SEVERAL SOURCES

THAT EVENTUALLY DIED
IN ONE END,

AND NOW ONLY ONE IS STILL CREATING AN ISLAND.

ANOTHER WAY TO DO IT WOULD BE
TO HAVE ONLY ONE PIPE,

BUT HAVE THAT PIPE MARCH ALONG BENEATH THE ISLAND CHAIN.

FIRES UP KAUAI,
AND THEN THE PIPE

DECIDES IT'S GOING
TO SOMEHOW ROLL FORWARD,

AND NOW IT'S GOING TO DRIVE UP AND FEED THE NEXT ISLAND, OAHU.

SO ESSENTIALLY, WE'RE GOING
TO PERFORATE THE PLATE

ONE AT A TIME BY MOVING
OUR HEAT SOURCE ALONG.

IT COULD BE ON A TRAIN TRACK DOWN THERE IN THE MANTLE.

THAT'S GOT A LOT OF PROBLEMS ASSOCIATED WITH IT,

BECAUSE WE WANT
SOME SOURCE OF HEAT

DOWN INSIDE THE EARTH
TO BE MOBILE.

WE SOMEHOW WANT THIS THING
TO MOVE LATERALLY,

RATHER THAN MOVE UP AND DOWN, THE WAY HEAT DOES.

SO...

WHAT IF WE
TRIED IT ANOTHER WAY?

MAYBE THERE IS ONLY
ONE SOURCE OF LAVA,

AND IT HASN'T MOVED, BUT MAYBE THE ISLANDS HAVE MOVED.

SO NOW OUR HEAT SOURCE PERFORATES THE CRUST

AND THE CRUST MOVES ON,
AND EACH TIME IT COMES THROUGH

AND MAKES A NEW VOLCANO,
WHILE THE CRUST MOVES BY.

AND AS THE PLATE MOVES AWAY,
OR THE CRUST MOVES AWAY,

THAT MOUNTAIN ALSO MOVES AWAY.

SO AS THE LAVA CONTINUES
TO COME UP

AT THE SAME PLACE,
IT'S NOW COMING UP

BEHIND THE MOUNTAIN
THAT WAS THERE BEFORE;

IT BUILDS A NEW MOUNTAIN.

AND IN THIS WAY,
WE CAN BUILD AN ISLAND CHAIN,

A STRING OF PEARLS,
AS YOU WILL,

OVER A FIXED HOT SOURCE
OR HOT SPOT.

Argow: SEISMIC EVIDENCE REVEALS A FEATURE DEEP UNDERNEATH HAWAII

THAT IS THOUGHT TO BE
AN INTENSE PLUME OF HEAT

THAT COULD BEGIN AS FAR DOWN
AS THE CORE-MANTLE BOUNDARY.

AS THE HEAT RISES
TOWARD THE CRUST, IT MELTS ROCK.

THE MELT IS BUOYANT
AND RISES TO THE SURFACE,

CREATING A VOLCANIC ISLAND.

UNLIKE SUBDUCTION-ZONE VOLCANOES,

WATER IS NOT A MAJOR INFLUENCE ON MELTING HERE.

THIS IS ONE OF THE REASONS
WHY THE HAWAIIAN VOLCANOES

TEND TO BE LESS GASEOUS
AND ERUPT LESS EXPLOSIVELY.

Sherrod:
BASED ON EVIDENCE WORLDWIDE,

THIS IS WHAT SCIENTISTS THINK
IS PROBABLY GOING ON --

THAT THE HOT SPOT
THAT HAWAII SITS OVER,

THIS HOT SOURCE,
WHATEVER WE WANT TO CALL IT,

THIS GENERATOR OF MAGMA,

THAT IT, MORE OR LESS,
IS FIXED IN A GLOBAL SCALE,

AND THAT THE CRUST UNDER
THE PACIFIC HERE IS MOVING.

BUT THE PACIFIC
IS A BIG, BIG AREA,

AND IN FACT, MUCH OF THE PACIFIC IS UNDERLAIN BY OCEANIC CRUST --

AND ALL OF THIS CRUST IS MOVING
IN THE SAME DIRECTION,

KIND OF HEADED TOWARDS JAPAN.

WE HAPPEN TO KNOW THE RATE -- ABOUT 10 CENTIMETERS A YEAR.

Argow: THE HAWAIIAN ISLANDS
ARE MERELY THE TAIL END

OF A 6,000-KILOMETER CHAIN
OF UNDERWATER EXTINCT VOLCANOES,

CALLED THE EMPEROR SEAMOUNTS.

SO FOR TENS OF MILLIONS
OF YEARS,

IT SEEMS THAT THIS HOT SPOT

HAS FUELED AND BUILT

LOTS OF VOLCANOES.

Reilly: IF WE FOLLOW
THE EMPEROR SEAMOUNTS,

WE RUN RIGHT
INTO THE RING OF FIRE.

SO THE PLATE
ON WHICH HAWAII EXISTS

IS BEING PULLED DOWN
INTO A SUBDUCTION ZONE.

IN ABOUT 100 MILLION YEARS,
HAWAII WILL BE RECYCLED.

Sherrod: FROM
A GLOBAL PERSPECTIVE,

THE HAWAIIAN ISLANDS
ARE MOVING.

THEY'RE GOING SOMEWHERE,
AND EACH ISLAND THAT FORMS

IS GOING TO BECOME EXTINCT,
GO BENEATH THE WAVES,

BUT THE PLATE
UPON WHICH IT RIDES

IS HEADED TO THE SUBDUCTION ZONE OFF JAPAN,

AND IT'S GOING TO GO DOWN
THAT SUBDUCTION ZONE,

WHICH MEANS THE ULTIMATE FATE
OF ANY HAWAIIAN ISLAND...

IS IN THE EARTH'S MANTLE,

AND MELTING.

ONCE IT MELTS, ONCE THAT
PLATE MATERIAL GETS SUBDUCTED,

IT CAN THEN BECOME PART
OF THE CONVECTION ENGINE

IN THE MANTLE
AND CAN BE RECIRCULATED,

SO TO SPEAK, OR RECYCLED.

Argow: BY LOOKING UNDERNEATH
THE PLATE ON WHICH HAWAII RIDES,

WE REVEAL THE FINAL KEY TO
THE MYSTERY OF WHY PLATES MOVE.

GEOLOGISTS BELIEVE
THAT HEAT IS GENERATED

IN THE DEEP INTERIOR OF
THE EARTH AND RADIATES OUTWARD.

THIS HEATS UP
MANTLE MATERIAL,

WHICH BECOMES BUOYANT
AND RISES TO THE SURFACE,

WHERE IT LATER COOLS
AND EVENTUALLY SINKS.

THIS CYCLE
OF HEATING AND COOLING

CREATES CURRENTS
INSIDE THE ASTHENOSPHERE.

THIS IS LIKE A FLAME
UNDER A POT OF SOUP,

WHERE HEAT CAUSES
VERTICAL CURRENTS,

WHICH REACH
THE SURFACE, COOL,

AND ULTIMATELY DESCEND AGAIN TOWARD THE SOURCE OF HEAT.

THERE, THE SOUP
IS WARMED UP AGAIN AND RISES,

COMPLETING A CYCLE
CALLED A CONVECTION CELL.

SCIENTISTS THEORIZE
THAT THESE CONVECTION CELLS,

PARTNERED WITH THE ACTIONS

OF SUBDUCTING PLATES
AND SPREADING MARGINS,

ARE WHAT DRIVE
PLATE TECTONICS.

Sherrod:
IS THAT IMPORTANT TO US?

WELL, WE'RE KIND OF
STUCK WITH IT.

IT'S LIFE ON EARTH.

MOST OF THE WORK IS DONE
AT THE SPREADING MARGINS,

THE ATLANTIC RIDGE,
MOST OF THE WORK

IS DONE IN SUBDUCTION ZONES.

THE HOT-SPOT ISLAND CHAINS
ARE MERELY ANOMALIES.

THEY'RE FAIRLY --
SOME OF THEM ARE LONG-LIVED --

IN THE CASE OF HAWAII,
PERHAPS AS LONG

AS 80 MILLION YEARS OR SO,
THE ISLAND-CHAIN PHENOMENON.

OTHERS ARE MUCH SHORTER-LIVED.

BUT IT SEEMS TO BE
ONE MORE PART OF THE PUZZLE

THAT CONVINCES US
THAT PLATE TECTONICS

IS INDEED
AN OPERATIVE PROCESS.

WHAT'S THAT SAY
ABOUT THE EARTH?

IT SAYS THAT THE EARTH
IS ONE BIG HEAT ENGINE

THAT'S STILL PUMPING IT OUT.

IT MEANS
THAT THE PRIMORDIAL HEAT

OF JUST MAKING THE EARTH COALESCE, THAT'S GONE,

BUT THE LONG-LIVED HEAT ENGINE, THE RADIOACTIVE DECAY,

NATURALLY OCCURRING DECAY

OF RADIOACTIVE ELEMENTS
IN THE EARTH'S CRUST,

IS STILL DRIVING THIS HEAT

THAT WANTS TO GET OUT
FROM THE CORE,

WANTS TO GET OUT
OF THE MANTLE,

IS CAUSING CONVECTION,

IS CAUSING SPREADING
OF THE COOL EARTH CRUST,

AND THE DIFFERENT BOUNDARIES THAT WE SEE BETWEEN THE PLATES.

THERE'S A LESSON THERE.

IT MEANS THAT PLATE TECTONICS
IS NOT FOREVER.

IT MEANS THAT
WHEN THE HEAT GOES AWAY,

SLOWLY, THE WHOLE
PLATE TECTONIC ENGINE DIES.

RIFTING BECOMES
LESS PROMINENT,

SUBDUCTION SEIZES,

VOLCANISM ENDS.

THE BIG ISLAND OF HAWAII
WILL JUST BE

A WHISPER IN SOMEONE'S MIND
AT THAT POINT.

Reilly: IN THIS SESSION,
WE EXPLORED

THE DYNAMIC WORLD
OF PLATE TECTONICS.

WE DISCOVERED
THAT WHEN TWO PLATES

SLIDE AGAINST ONE ANOTHER,
IT'S CALLED A STRIKE-SLIP FAULT.

THIS MOVEMENT RELEASES VIBRATIONAL ENERGY,

CALLED AN EARTHQUAKE.

WE LEARNED THAT
WHEN AN OCEANIC PLATE

COLLIDES
WITH A CONTINENTAL PLATE,

THE OCEANIC PLATE SUBDUCTS BACK INTO THE EARTH'S INTERIOR.

STRATOVOLCANOES
ARE A RESULT OF THIS COLLISION.

THEN WE EXAMINED OCEANIC SPREADING RIDGES,

WHERE TWO PLATES MOVE
AWAY FROM ONE ANOTHER

AND MAGMA
RISES TO THE SURFACE,

CREATING THE WORLD'S
MOST ACTIVE VOLCANOES.

FINALLY, WE DISCOVERED
THAT THE HAWAIIAN ISLANDS

ARE BELIEVED TO HAVE FORMED
OVER A HOT SPOT --

A PLUME OF HEAT THAT MELTS ROCK AND SENDS MAGMA TO THE SURFACE.

BRITT, WE TALKED
A LOT TODAY

ABOUT OCEANIC PLATES,

BUT WHAT ABOUT
THE CONTINENTS?

THEY DON'T SEEM
TO BE PART

OF THIS
PLATE-TECTONIC ENGINE

THAT WE'VE
BEEN DISCUSSING.

IT'S AS IF THEY'RE
JUST ALONG FOR THE RIDE.

WELL, CONTINENTS
MAY NOT SUBDUCT, JOE,

BUT THAT DOESN'T MEAN
THAT PLATE TECTONICS

DOESN'T PLAY
A HUGE ROLE

IN DEFINING
THEIR APPEARANCE,

THEIR SHAPE,
AND THEIR PLACEMENT

ON THE PLANET.

WE'VE LEARNED ABOUT
DIVERGENT PLATE BOUNDARIES,

WHERE PLATES MOVE APART.

WE'VE LEARNED
ABOUT TRANSFORM BOUNDARIES,

WHERE PLATES
SLIDE PAST EACH OTHER.

AND WE'VE ALSO LEARNED
ABOUT SUBDUCTION ZONES,

A TYPE
OF CONVERGENT BOUNDARY

WHERE TWO PLATES COME TOGETHER AND ONE IS FORCED DOWN.

BUT THERE'S ANOTHER TYPE
OF CONVERGENT BOUNDARY.

AND THAT'S WHAT
WE'RE GOING TO INVESTIGATE

IN OUR NEXT SESSION --
WHEN CONTINENTS COLLIDE.

I'M BRITT ARGOW.

AND I'M JOE REILLY.
SEE YOU NEXT TIME.

FUNDING FOR THIS PROGRAM
IS PROVIDED BY ANNENBERG/CPB,

TO ADVANCE EXCELLENT TEACHING.

FOR INFORMATION ABOUT THIS

AND OTHER
ANNENBERG/CPB PROGRAMS,

CALL 1-800-LEARNER,

AND VISIT US AT
www.learner.org.