WGBH/NOVA
#4222

Making North America: Human

00:00

KIRK JOHNSON *(Sant Director, Smithsonian National Museum of Natural History)**:** North America, the land that we love: it looks pretty familiar, don't you think? Well, think again! The ground that we walk on is full of surprises, if you know where to look.*

As a geologist, the Grand Canyon is perhaps the best place in the world. Every single one of these layers tells its own story about what North America was like when that layer was deposited.

So, are you ready for a little time-travelling?

I'm Kirk Johnson, the director of the Smithsonian National Museum of Natural History, and I'm taking off on the fieldtrip of a lifetime,

Look at that rock there. That is crazy!

In this episode, North America is locked behind an enormous wall of ice. How did the first humans to ever set foot on the continent manage to get in?

This is not the easiest thing in the world.

01:10

Once they got here, the challenges were daunting, but somehow, we turn the rocks of our homeland…

Oh, man!

…into riches.

This thing is phenomenal.

But what challenges lie ahead? Because our continent may be hiding some pretty dangerous secrets. Making North America: Human*, right now, on NOVA.*

Today, North America boasts fertile farmlands, gleaming cities, the incredible wealth of our land, supporting a population of over half-a-billion, but rewind the clock, just 15,000 years, and our continent was truly a wild kingdom, filled with amazing Ice Age creatures. Still, there was one animal found nearly everywhere but here: us.

04:43

So, how, in the blink of a geologic eye, did we turn an unpopulated continent into a rich and dynamic civilization? And what surprises does our homeland still hold in store?

The story of humans in North America begins with ice.

04:23

Alaska's Mendenhall Glacier: a 13-mile-long expanse, thousands of feet thick. This particular ice has been here for centuries. It may not be as old as rock, but, for a geologist, it's no less intriguing, if a bit risky.

JARED <NEEDS LAST NAME AND IDENTIFIER>: Just a bad place to trip.

KIRK JOHNSON: *I guess there's that, isn't there?*

JARED <NEEDS LAST NAME>: Yeah. Once you start falling on this ice, you keep falling until you hit something flat.

04:58

KIRK JOHNSON: *Fifteen-thousand years ago, this is what much of North America looked like. By then, humans had migrated from Africa to Europe, Asia and Australia, not yet to the Americas. But that was about to change.*

North America was in the grip of an ice age. So much of the world's water was locked up in ice sheets that sea levels dropped, exposing a thousand-mile-wide expanse of land that connected Siberia to Alaska, the Bering Land Bridge.

In the summer, this would have been a huge open expanse, allowing ancient hunter-gatherers from Siberia to migrate east, into North America. But the open landscape abruptly ended at the edge of a vast ice sheet, in what is now southeastern Alaska.

6:06

Would they have tried to cross it?

JARED <NEEDS LAST NAME>: Ready for this?

KIRK JOHNSON: *I think so.*

JARED <NEEDS LAST NAME>: Here we go.

A little bit higher and to your right, and you should be good.

KIRK JOHNSON: *This is not the easiest thing in the world. It's hard to imagine somebody crossing even one ice field like this, much less an entire ice sheet. This is insane.*

Glaciers are perilous: ever shifting and often unstable. Early explorers would have had a tough time getting very far.

06:47

Imagine trying to cross big ice sheets, a hundred miles wide, couple thousand feet high, into North America.

Based on this, I'm pretty sure that people, if they came into North America at that time, didn't go over the ice.

JARED <NEEDS LAST NAME>: Looking good, buddy!

KIRK JOHNSON: *So how did the first Americans wind up on the other side of this daunting barrier?*

07:20

The traditional view is that when the climate began to warm, about 13,000 years ago, melting, along a seam between two great inland ice sheets, opened a corridor. But there's another potential route to the rich land beyond the ice, first hinted at by a discovery made over 1,000 miles to the south, off the coast of California.

Twenty-five miles from Santa Barbara lie the remote and windswept Channel Islands. Here, on Santa Rosa Island, a little over 50 years ago, a lone archaeologist stumbled upon some of the very earliest human remains ever found in North America.

Joining me is Joe Watkins, a National Park Service anthropologist and a member of the Native American Choctaw tribe. He's taking me to a spot that has tremendous meaning to native peoples and scientists, alike.

JOE WATKINS (National Park Service)**:** This is a very important place. It's what brings us to Santa Rosa Island.

KIRK JOHNSON: *Well, there's a nice bluff right there.*

JOE WATKINS: Yep.

8:42

KIRK JOHNSON: *Right here, in an area called Arlington Springs, back in 1959, archaeologist Phil Orr spotted a couple of distinctive bones, revealed in the weathered cliff.*

Joe has a replica.

But it's, it's clearly a thighbone. There's the knee joint, and there should be a ball on the…

JOE WATKINS: Here it is.

KIRK JOHNSON: *That fits on, that fits on right there. So, I've got a thighbone of a human.*

JOE WATKINS: Right, exactly. And there were two femurs that came out. They come from a man about five foot, one inches tall. But it's the age that has put the prehistory of North America on its ear.

9:25

KIRK JOHNSON: *Named Arlington Man, these bones date to around 13,000 years ago. They're among the oldest human remains ever to be discovered in North America.*

More than 13,000 years ago puts these bones during the last ice age.

JOE WATKINS: Exactly. And that's what makes them significant.

KIRK JOHNSON: *Significant, because, not only was Arlington Man one of the earliest known inhabitants of North America, but he lived and died here, on an island miles off the coast.*

JOE WATKINS: That means that Arlington Man or his ancestors probably got here by boat.

KIRK JOHNSON: *That's an amazing fact. They didn't walk here, they paddled here.*

10:11

If boats were in use here, then they were probably in use all along the coastline, from Alaska to South America. They may have been similar to traditional Inuit boats, wooden frames, covered with walrus hides; agile and rugged vessels. This kind of technology could have opened a way south, even before the ice sheets melted.

JOE WATKINS: So, if you figure boats into the equation, it really opens up a whole different set of possibilities. You don't have to go through the ice, you can just paddle down the coastline.

KIRK JOHNSON: *Using boats to probe the shore would have opened the way for seafaring hunters to settle along the western edge of the continent. And, as they made their way into this unexplored land, what untapped riches would they have found?*

11:20

Luckily for us, there are a wealth of clues in the unique geology of Southern California, extracted over the years from an iconic tourist attraction, the La Brea Tar Pits.

This is one of the greatest fossils sites in the world, and it's right in the middle of Los Angeles. Shallow pools of natural sticky asphalt have been bubbling up from below the surface here, for tens of thousands of years,

creating a lethal trap for unsuspecting animals and a perfect graveyard for their bones.

Hey, Carrie. How's it going?

CARRIE HOWARD (Lead Preparator)**:** Hi, Kirk. How are you?

11:59

KIRK JOHNSON: *Carrie Howard is a paleontologist, working with an incredible trove of animal fossils, all pulled from the pits. What these bones tell us is that this area was once a great hunting ground and not just for ancient people.*

12:17

Wow, that's a nice skull.

CARRIE HOWARD: Oh, yeah. This is a saber-tooth cat skull.

KIRK JOHNSON: *It sure is.*

CARRIE HOWARD: As you can tell, it would have stabbed or sliced its prey, we believe.

KIRK JOHNSON: *I mean, one in, boom you're done.*

Wow, so think about that, just about the time that people showed up in North America for the first time, these guys were waiting to greet them—a bad day in California.

More than a million bones have been found here in the last century, the largest from huge mammoths that weighed up to 12,000 pounds. All told, something like 620 different species of plants and animals have been identified.

12:58

CARRIE HOWARD: Bison Scapulae.

KIRK JOHNSON: *Horse neck vertebrae.*

CARRIE HOWARD: More bison leg bones. These are really great.

KIRK JOHNSON: *Wow, look at those things, that's a huge animal.*

CARRIE HOWARD: Big camel vertebrae.

KIRK JOHNSON: *Wow. Toes of camels and more camels and more camels! There are a lot of camels here.*

CARRIE HOWARD: Yeah, not many people know camels originated in North America.

KIRK JOHNSON: *It's amazing that there were camels in Los Angeles.*

13:27

For Ice Age hunters, the mammoth would have been particularly valued, each one providing thousands of pounds of meat, if you could bring it down.

What kind of a weapon could have evened the odds?

To track down an answer, I head to Boulder, Colorado.

A few years ago, Patrick Mahaffy was having some landscape work done behind his house. One day, when he checked in with the work crew, he got an unexpected report.

PATRICK MAHAFFY (Homeowner)**:** I got home from work, and it had been a very busy day for them. I asked, like you do on a project, "How did the day go?" And they went through this list of all the things they'd done. And then they said, "Oh, there's one last thing. We found something."

KIRK JOHNSON: *They found what seemed to be an intentionally buried cache of mysteriously-shaped stones.*

14:33

DOUGLAS BAMFORTH (University of Colorado)**:** That one is amazing.

PATRICK MAHAFFY: That is amazing.

KIRK JOHNSON: *Archaeologist Doug Bamforth was called in to take a look.*

DOUG BAMFORTH: I regularly get phone calls about people's discoveries, but I don't get very excited, because they usually don't turn into much of anything. But then I went up there the next day, and it was just breathtaking.

KIRK JOHNSON: *An 83-piece Stone-Age toolkit, each piece carved by ancient hands.*

DOUG BAMFORTH: There's a good sharp edge. You could only hold it between the tips of your fingers, right. You could do light cutting.

15:09

KIRK JOHNSON: *Thirteen-thousand years ago, these sharpened stones would have been the most advanced technology on the continent.*

DOUG BAMFORTH: You have to imagine a world with no metal in it. All the things that we rely on to cut things and scrape things and do almost all of our physical work, right, the fundamental material that we use did not exist in the world.

KIRK JOHNSON: *Like other early human societies, North Americans relied on stone. So Doug wanted to know, "How old were the tools in this collection?"*

15:44

To find out, Doug decided to test for D.N.A. residue that might give him a clue about the age. Incredibly, he found traces of blood from several species of animals. Two, in particular, surprised him.

He found D.N.A. from the ancestors of modern day horses and camels, species that once lived in North America, around the end of the Ice Age, clear evidence that these tools were once used by some of the earliest American hunters.

DOUG BAMFORTH: Getting artifacts that have blood residue on them from camels and the horses tells us that these are among some of the oldest tools we know about, in North America, so, evidence of some of the very earliest people who were here.

16:42

KIRK JOHNSON: *The most lethal hunting weapon they devised was a spear tip known as a Clovis point, named after the site where it was first discovered, in New Mexico.*

Clovis points all share a common design, a symmetrical, fluted shape, with sharp edges on both faces. Since then, at least 4,000 Clovis points have been found across North America, a sign that the First Americans traded weapons-grade rock and the latest hunting technology over hundreds of miles.

Bob Patten has been crafting Clovis point replicas for over 40 years, and he's offered to show me just how tricky it can be to coax a sharp-edged weapon from a stone.

BOB PATTEN (Author and Flint Napper)**:** These are antler.

KIRK JOHNSON: *Oh, I see.*

BOB PATTEN: That catches the blow. I want you to reach forward a little bit.

KIRK JOHNSON: *Wow, my first flake. Awesome!*

17:40

We're using a rock called "chert." It's similar to flint and was favored by Stone Age toolmakers, because of a very special property: with a bit of persuasion, the rock will break off razor-sharp flakes.

BOB PATTEN: This is better than an X-ACTO® knife.

KIRK JOHNSON: *Wow, you're cutting leather with a rock. You can cut with great precision there, too.*

I can see the spear point in there. I just can't quite get to it.

BOB PATTEN: Right.

18:09

KIRK JOHNSON: *Bob's going to put the finishing touches on my Clovis point. He seems to have a knack of finding just the right spot to hit the stone.*

BOB PATTEN: It's a very subtle thing, and you have to train yourself, in order to do it consistently.

KIRK JOHNSON: *Now, we've got a tool that we can go hunt a mammoth with!*

BOB PATTEN: Oh, you'd put it on something fairly long, because a mammoth is a big animal that you don't want to get too close to, until he's dead.

18:36

KIRK JOHNSON: *It's hard to imagine how a relatively small stone could bring down an animal the size of an elephant.*

To test its killing power, I'm going to use a block of ballistics gel. It's a material used to test firearms, because it the same consistency as flesh.

BOB PATTEN: You've got the mammoth; I've got the spear.

KIRK JOHNSON: *A piece of animal hide covers the front of the ballistics gel, so I'll be able to see how well the spear point penetrates skin, too.*

All right, so the angle is here. It's like shooting a pool cue.

Wow, the blade went in like it was going into a block of butter. When it hit the actual shaft, that's when it stopped.

BOB PATTEN: Well, I think we know why that style of point was so successful.

KIRK JOHNSON: *Yeah, that thing really worked.*

BOB PATTEN: It does cut. And we should be ready to go and conquer the continent.

KIRK JOHNSON: *Clovis points have been found embedded within the bones of mammoths, demonstrating just how successful these weapons could be in bringing down even the biggest beasts.*

These Clovis spearheads are exquisite artifacts. They're just beautiful things to behold, but, in reality, they were lethal killing machines.

20:21

By 12,000 years ago, mammoths, saber-toothed cats, dire wolves, camels and many other large mammals had all but disappeared, likely the victims

of an expanding human population and a changing climate. But others thrived, on a landscape that offered more than a million square miles of grass-covered prairie, home to a North American icon.

20:40

JOE WATKINS: On the Great Plains, these oceans of grasses were the primary food for millions of bison. These bison were the "supermarket-on-the-hooves" for the nomadic Native American tribes that hunted them. The bison hides could be used for housing. They've **<THEY MADE OR THEY'D HAVE MADE?>**made them into teepees that could be put up and taken down in a matter of minutes, just so that the Native American tribes could follow the herds from one spot to the next. For 10,000 years, this was their staple food.

KIRK JOHNSON: *The geology of North America created a landscape ideally suited to support abundant animal life, sustaining a growing human population.*

21:39

But not all Native Americans hunted for a living. In Colorado's Mesa Verde National Park, I've come to see a genuine wonder of the ancient world. Tucked away, in these rocky hills, stands an 800-year-old architectural masterpiece called Cliff Palace.

Oh, man. That is so awesome.

Built from finely laid sandstone slabs, pine beams and mortar, beneath natural overhangs, this 150-room complex was home to the Ancient Puebloans, forbearers of today's Puebloan Peoples.

This is a massive set of structures here. So, these were people that really invested in real estate.

SCOTT TRAVIS (Mesa Verde National Park Archaeologist)**:** Uh, huh. Yes.

KIRK JOHNSON: *Scott Travis is the park archaeologist.*

SCOTT TRAVIS: It's characteristic of cliff dwellings at Mesa Verde to have this type of scale, but nothing approaches the sheer size of this particular site.

KIRK JOHNSON: *And this original cave-like structure is a natural formation in the sandstone?*

SCOTT TRAVIS: It's just a natural part of the evolution of these canyon systems.

KIRK JOHNSON: *These formations, along with others like them, provided shelter for thousands. And for centuries, the people here worked the land as farmers, even though conditions were often tough.*

23:19

JOE **< SCOTT TRAVIS?>:**: Mesa Verde is a wonderful example of how the Ancestral Puebloans took advantage of their local situation. Not only did they create remarkable architecture within the alcoves, they were able to farm in one of the harshest environments on the continent. They did this with a combination of expert geological knowledge and the ability to control scarce water resources, to farm in a situation that is difficult, even today.

KIRK JOHNSON: *And other farming cultures did even better, using their resource wealth to build big cities and giant places of worship, like the builders of the mysterious mounds at Cahokia, Illinois, who raised corn to support a city of 15,000; or the Maya of Central America, who built canals and irrigation networks that sustained great stone cities. Hundreds of thousands lived in the Aztec capital in central Mexico at the end of the 15th century.*

But the story of human interaction with the geology of North America was about to be turned on its head, by the arrival of outsiders.

24:41

Western European explorers opened the way for conquerors, colonists and their slaves, who would all, ultimately, displace most of the native population. What drew so many to voyage so far into an unknown world?

To find out, I'm traveling to North Carolina, to a research station that studies a native plant that enticed European settlers with a promise of riches.

It's pretty cool. I have never been in one of these tobacco fields before.

DAVID MONTGOMERY (**<CO-?>**Author, *The Hidden Half of Nature*)**:** This is the plant that got North America started as a British colony.

KIRK JOHNSON: *The first cash crop?*

DAVE MONTGOMERY: It was the one that, economically, could keep the early colonists in business, and, in great part, because there was a perfect storm of the right plant, brought to the right place, in the right climate, at the right time, with, importantly, the right kind of soil for growing it.

KIRK JOHNSON: *Huh.*

25:37

Dave Montgomery studies how the earth's thinnest and most fragile geological layer has shaped the destinies of human societies, including ours.

So what is soil?

DAVE MONTGOMERY: So, soil is sort of the frontier between the worlds of geology and the world of biology. It's that interface. And it's made dominantly of rotten rocks.

KIRK JOHNSON: *But what kind of rotten rock? Dave reveals the recipe that makes life on land and all agriculture possible.*

DAVE MONTGOMERY: First ingredient is sand.
26:13
KIRK JOHNSON: *Sand is any mineral, ground down into tiny grains by natural wear and tear.*

This looks like a nice beach sand, there is little quartz grain, little clear grains of quartz is what I am seeing.

DAVE MONTGOMERY: Yeah, quartz and feldspar. It's not unlike a California beach.

KIRK JOHNSON: *Silt is next, made of the same stuff as sand but ground much finer.*
26:38
DAVE MONTGOMERY: It's too small to really see, but you can feel the grit. If you put a little on your teeth, you will feel the grit between your teeth.

KIRK JOHNSON: *Oh, yeah. It's really gritty. No, I don't really like eating silt.*

DAVE MONTGOMERY: No.

KIRK JOHNSON: *The finest is clay, made up of mineral crystals so tiny, they're visible only with a microscope.*

These are all…this is all geology, still?

DAVE MONTGOMERY: This is all geology. This is the basis, the backbone of making a soil. And the geological part, some combination of these three components, makes up about 40 percent to 50 percent of the volume of most soils.

KIRK JOHNSON: *So what's the rest?*
27:12
How about the rich black stuff we associate with fertile soil? The stuff of life or, actually, of death.

So it's nice and dark. It looks like coffee grounds.

DAVE MONTGOMERY: This is rotted plant matter, and so you have got pieces of plants.

KIRK JOHNSON: *Oh, this smells nasty. I guess it's dead stuff though, right?*

DAVE MONTGOMERY: It's dead stuff. That's why it smells so good.

KIRK JOHNSON: *I'm going to put this back in the jar. So that's it, these four things?*
27:37
DAVE MONTGOMERY: Well, then there is also living matter, which, in this case, we have worms. So, you can think of them the way that Charles Darwin did, as God's "plowman." They basically plow the fields.

KIRK JOHNSON: *Underground, they are like real underground miners.*

There's one last ingredient, a geologist's best friend.

We have time in a jar, here?

DAVE MONTGOMERY: We have got time in a bottle, here. We are not going to open it.

KIRK JOHNSON: *How much time do you have in that bottle?*

DAVE MONTGOMERY: There is only one way to find out.

KIRK JOHNSON: *Don't open that jar. Don't open that jar. It can be, like, a million years in that jar.*

DAVE MONTGOMERY: It could be.
28:14
KIRK JOHNSON: *The British colonists got lucky when they chose to plant tobacco here. For tens of thousands of years, nature had been preparing the soil along the southeast coast, giving it all the right ingredients, especially an extra helping of sand, perfect for growing the original wacky weed.*

But they soon paid a price. It's not hard to see what growing millions of pounds of tobacco to ship back home did to the land. Even today, comparing soil from the forest to soil from the tobacco field tells the whole story.
28:57
DAVE MONTGOMERY: So, over here, on this side, we have got the forest soil, which is probably a lot more like the native soil was like, when colonial agriculture arrived in the New World.

KIRK JOHNSON: *Yeah, lots of organic matter in it and roots and twigs and stuff like that.*

DAVE MONTGOMERY: You notice the dark color, relative to the soil next to it, which is from the conventionally plowed tobacco field.

KIRK JOHNSON: *The sickly yellow color shows the soil's exhaustion.*

These fields are lush today, thanks to chemical fertilizers, but the colonists had no such tricks, and growers soon hit a wall.

29:30

DAVE MONTGOMERY: The erosive effects of colonial agriculture were so apparent on the American landscape that people at the highest levels of American society were very concerned about what it meant for the future of the country.

Washington even wrote, in a letter in the 1790s, to Alexander Hamilton, about his prediction that American society would be compelled to push inland, to push westward, due to the search for fresh and fertile soils, after having worn out the soils along the eastern seaboard.

KIRK JOHNSON: *But the Founding Fathers needn't have worried, because migrating farmers would soon discover the Great Plains, with some of the best soil in the world.*

DAVE MONTGOMERY: The dirt is destiny in that sense, where degrading the soils of the eastern seaboard and then opening up the fresh fertile soils in the American Midwest served like a great magnet, pulling people westward, towards the source of fertility and prosperity in the heart of the country.

KIRK JOHNSON: *The great magnet of North American soil exerted an irresistible pull on those with a pioneering spirit. But the westward expansion also got a major shot of adrenaline, with the discovery of a new gift from the geology of the continent: gold.*

30:56

In 1848, Mexico ceded to the U.S. a territory that included what would become the state of California. At the time, San Francisco was little more than a military garrison, with a population under 1,000. But that changed when James Marshall found nuggets of gold in a streambed at Sutter's Mill, in Coloma, California. When word got out, California became a hot destination. In 1849, about 80,000 people, called "'49ers," joined the Gold Rush. And over the next six years, about 200,000 more followed, turning San Francisco into one of the largest cities on the continent.

By then, prospectors had snatched up pretty much all the gold to be found just lying around and so the party had to move underground.

32:03

Pretty sweet place, hey?

LISA WHITE (University of California Museum of Paleontology)**:** Yes, it's beautiful here.

So, they started mining around here in 1849.

KIRK JOHNSON: *Lisa White is a geologist and a native San Franciscan. Her passion for California's amazing geological history was bred in the bone.*

LISA WHITE: Let's go have a look.

32:26

KIRK JOHNSON: *Who better to show me this historically preserved mine in the Sierra Nevada Mountains?*

The miners must have been short guys.

LISA WHITE: Well, I fit right in here.

KIRK JOHNSON: *Yeah, not me.*

LISA WHITE: This is such an incredible mine, for so many different reasons. Unbelievably, they dug out the earliest part of this mine by hand.

KIRK JOHNSON: *Wow, look at that. You can actually see the pick marks where they carved this thing.*

32:52

As Lisa leads me further into the mountain, we spot a change in the rock.

LISA WHITE: Ah, here we go.

KIRK JOHNSON: *That's something different.*

LISA WHITE: It is, it is. It's a quartz vein. It's important and distinctive, because when the miners would locate these quartz veins, they knew they were in the area they wanted to be in for gold.

KIRK JOHNSON: *So the gold is actually in the quartz?*

LISA WHITE: The gold is in the quartz, yes, it is. And so, looking for these was the way to the gold.

I've got a quartz sample here, in my pocket, with some gold flakes in it.

KIRK JOHNSON: *Wow, there are a lot of flakes there aren't there?*

LISA WHITE: Right, it's really beautiful.

KIRK JOHNSON: *Yeah, if you like gold. But the gold is in the quartz but not in the rock next to the quartz?*

LISA WHITE: Exactly, so that's key to understanding its formation.

33:44

KIRK JOHNSON: *When Earth was forming, most heavy metals, like iron and gold, sank to the molten core, but small amounts remained in the rocky mantle as Earth cooled. Later, asteroids deposited more of these metals. But for gold to work its way back up to the surface, it had to hitch a ride on some kind of geological shake up, like an earthquake.*

34:17

Violent earthquakes, like this one, in San Francisco, cause serious damage above ground, but they also wreak havoc below the surface.

LISA WHITE: I mean, most people know that California is earthquake country. But even in the past, earthquakes were key, because earthquakes would fracture the rocks, and, in many ways, the cracks, they're like pathways for fluids from deep within the earth.

KIRK JOHNSON: *Deep below, millions of years of earthquakes and pressure from molten rock have created a network of cracks. These provide pathways for superheated water, full of minerals like gold, from deep in the earth.*

When that hot fluid rises up through the fractured rock, it cools down, and the minerals carried within crystalize. Over time, that builds up a vein of quartz, and anything trapped inside the quartz are bits of gold.

35:18

Over millions of years, they formed the seams found all over California.

LISA WHITE: So, every time you look at a vein of quartz you're really seeing an ancient earthquake, in many ways.

KIRK JOHNSON: *I've always thought of earthquakes as very destructive kinds of things, but looking at this is* ***<AS rather than IS?>****earthquakes are involved in the formation of gold, maybe there's a silver lining…a gold lining to earthquakes.*

The California Gold Rush didn't last very long, but between 1848 and 1860, it's estimated that more than a million pounds of gold were found in these hills.

Over the following years, much of it made its way right here, to the Old Mint in San Francisco. Affectionately called the "Granite Lady," this building once held the machinery that turned California gold into beautiful coins. It's no longer in operation, but there's a vault here that's holding something that, these days, is truly rare,…

Oh, ho, man. This thing is phenomenal.

36:35

…a massive nugget of gold, the largest to be found in California in decades, worth around $400,000 dollars.

It was probably buried about 40-million years ago, and it was dug up a few months ago. Gold is so dense that it doesn't look that large, but it feels really heavy. It's like five pounds packed into the palm of my hand.

You feel both the power of the earth and geology and chemistry, but you also feel the weight of human history. Gold has driven the behavior of humans since it was first found.

I actually have gold fever right now. I want to take a bite out of this thing. It's an amazing thing.

37:22

Striking it rich in gold or silver was the dream of thousands of prospectors, but what other treasures did the geology of the continent have to offer? Turns out, the real money was about to be made back east, in the iron and coal mines poised to power the nation's next great leap.

37:55

By the 1860s, the industrialization of the American economy was going full steam, literally.

Unbelievable.

Perhaps the one technology that best symbolized the massive transformation underway was this: the steam locomotive.

In 1863, the U.S. government launched an ambitious effort to unite the coasts with a transcontinental railroad. Two railroad companies set out to meet in the middle. Progress from the east was relatively rapid, thanks to the wide open prairie and a natural pass through the Rockies, but construction of the western line made progress much more slowly, impeded by the Sierra Nevada Mountains.

The only option: cut a pass by hand. From this logging train, we can see just what they were up against.

This is granite, incredibly hard rock, and the people that had to build the first railroad across the Sierra Nevada's cut through this rock with hand tools, sledge hammers, steel drills and explosives, incredibly hard work.

39:27

They relied heavily on Chinese immigrant laborers. In harsh conditions, they carved 15 tunnels, largely using hand tools and dynamite. The longest stretched about a third of a mile and took 15 months to complete. Eventually, the two lines met in Utah, on May 10, 1869. It had taken six years, but America's new, East-West railroad was open for business.

The building of the transcontinental railroad was an epic endeavor. But once it was done, it linked the United States from coast to coast, and within 50 years of that, there was a quarter of a million miles of railroad tracks ***<VERIFY "WAS…TRACKS">****spanning the continent.*

40:26

And with the two coasts linked, the economy roared, fed by the continent's abundant geological gifts of coal, metals and other resources, and eventually, by a powerful new fuel.

I've come to the great city of Los Angeles. It's an amazing metropolitan area, something like 18-million people live here. That's a lot of people and they use a lot of resources.

It's no secret that Los Angeles has an insatiable thirst for oil. But what's less well known is the area's history as a major producer. That story takes me back to the La Brea Tar pits.

The natural asphalt that trapped so many ancient animals is actually a form of oil. Paleontologist Carrie Howard takes me into one of the fossil pits to see L.A.'s "black gold," up close.

I'm just dying to get down in there and scrape some of those bones right now. But if I did that, I would actually probably be stuck, right?

CARRIE HOWARD: Yeah. Even if you just stepped right there, don't be fooled, even, like, an inch could stick your shoe, and then you'd definitely need help.

42:07

KIRK JOHNSON: *This sticky oil was produced by the slow accumulation and burial of marine plankton, over millions of years. Compressed and heated under ground and* ***<IT rather than AND?>*** *turned into thick oil. It's managed to seep upwards, to bubble up, here. It may not seem like much, but there's a lot more where this came from.*

These tar pits, with their fantastic fossils, are just the tip of the iceberg, because deep beneath the streets is a tremendous amount of oil.

Once Californians realized the scale of this geological treasure, they, kind of, went nuts exploiting it.

What I've got here is a picture from 1901 of this very spot. And I can see a house down there that's in this photograph. But what's not here today are the dozens of oil derricks that were here in 1901. This place was an incredible oil field.

43:02

Oil is really the D.N.A. of Los Angeles. It was discovered here, first, in 1892, and it kicked off an amazing oil boom. And even today, Los Angeles

is defined by oil. In and around Los Angeles, there are oil wells almost everywhere.

Pretty amazing, right here in the middle of a neighborhood is a full on oilrigs ***<OILRIG?>****.*

43:35

There's a house, and there's a pump jack, and a house and a pump jack.

Looking down—and it's a great view of the city of Los Angeles—there's oilrigs all over the place, down there. Los Angeles County has more than 3,000 active oil wells, tirelessly pumping more than 14-million barrels a year. But that's just a tiny fraction of total North American output.

44:08

From Mexico to the oil sands of Alberta, Canada and the Arctic Coast, we're pumping oil and natural gas out of the ground at a record rate. Which begs the question: should we?

When we burn fossil fuels, the release of carbon dioxide causes Earth's atmosphere and oceans to warm. As a result, glaciers are melting and sea levels are rising much faster than at the end of the last ice age.

Our impact on the land is a huge concern, but, as a geologist, I also worry about the nasty surprises our continent has in store for us. In the Pacific Northwest, there are chilling clues about a future natural disaster.

This is this old-growth rainforest. Some of these trees are more than 500 years old, and they've witnessed events we can barely imagine. And its trees like these, not too far from here, that played a key role in resolving a mystery of epic proportions.

Meet geologist Brian Atwater. He and I are paddling up the Copalis, a coastal river that rises and falls with Pacific Ocean tides. We're here at low tide, but, at high tide, the river can rise enough to overflow its banks, flooding the surrounding marshes with saltwater.

But it wasn't always that way. Once, this was a lush coastal rainforest. Now, all that remains are massive roots, sticking out of the eroded riverbank, and the trunks of long-dead cedar trees: a ghost forest.

46:19

Brian has brought me here to show me evidence of one of the worst earthquakes to hit North America since human beings arrived here. He's found signs in a place where geologists feel right at home, in the mud. Slicing into the bank, reveals three layers. They tell a story of change over time. The lowest once supported a healthy rain forest.

BRIAN ATWATER (U. S. Geological Survey)**:** So this is almost like a garden soil, but it has tree roots in it, so it's a forest floor soil.

KIRK JOHNSON: *Just above, is a layer of sand. Entirely out of place, its sharp definition tells Atwater that whatever put it here came fast and furious.*

47:17

BRIAN ATWATER: You don't see sign of a gradual change from here, because there is such a black and white difference between this and this. How do we do this combination? How do we go from forest floor to some kind of muddy flat and have a sand layer brought in first, right at that time?

KIRK JOHNSON: *The answer lies about 80 miles away, at the bottom of the Pacific Ocean. It's called the Cascadia subduction zone, a 700-mile long crack in the crust of the planet. It's where a Pacific Ocean plate is trying to slide under the North American plate, but the plates are stuck.*

48:03

BRIAN ATWATER: So there **<THE?>**story there you know is the down-going oceanic plate, the overriding continental plate, stuck together here. They go closer and closer like that, and the overriding plate gets shortened, bulges up.

KIRK JOHNSON: *The old-growth forest that once stood around the Copalis River, sat on that bulge. But then, the plates broke free along the fault, causing a violent earthquake, dropping 600 miles of coastline as much as five feet and into the tidal zone, where it sits today.*
The local landscape drops.

BRIAN ATWATER: The ghost forest goes for a swim.

KIRK JOHNSON: *That's it for them.*

But the disaster wasn't over. That same tectonic rupture also drove the edge of the continental plate upward and triggered a series of huge waves, a tsunami.

49:03

BRIAN ATWATER: The tsunami comes in, that's the first thing the forest gets to see.

KIRK JOHNSON: *What the forest sees is a rush of saltwater and sand inundating the land, the final blow from a massive fault rupture that turned an old-growth rainforest into this.*

We now know that this cataclysmic one-two punch took place in the year 1700. Today everyone wants to know: will it happen again? Is the Pacific Northwest living on borrowed time?

PEDRO <NEEDS LAST NAME AND IDENTIFIER>: Tsunami is running.

KIRK JOHNSON: *At Oregon State University, Chris Goldfinger studies deep-sea earthquakes that can cause devastating tsunamis. He's examined hundreds of sediment cores from the sea floor, sampled all along the 700-mile Cascadia subduction zone.*

50:21

Analyzing each one, he's assembled a history of earthquakes going back 10,000 years. And the news is not good. Chris estimates that severe earthquakes strike somewhere along the fault line about every 240 years, most often in Oregon and Northern California.

CHRIS GOLDFINGER (Oregon State University)**:** We are 315 years into a 240-year average. And so that drives the probability up quite a bit, up to 37 percent in the next 50 years.

50:55

KIRK JOHNSON: *Today, seismologists warn that the next big one in the Northwest could be even more violent than the earthquake and tsunami that struck Japan in 2011. Luckily, there is time to prepare, thanks to a warning from an ancient disaster, written in the land.*

Geology gives us many, many examples of how interrogating the earth's past prepares us for the earth's future. The relentless forces beneath the earth will continue shaping our continent, far into the future, as they have from the very beginning, since the first land formed from molten rock and the pieces of our homeland slid into place, as seas and mountains rose and fell, as creatures small and mighty lived and died here.

Geology has profoundly shaped our destinies, ever since we set foot upon these shores. Soil, oil, minerals, the power of the rocks beneath our feet cannot be ignored. So what can we expect, not just in our lifetimes, but over the serious long haul?

52:26

Well, over the next one-hundred-and-seventy-five-million years, geologists predict that North America will slowly converge with Europe and Africa until, eventually, the Atlantic will completely close, and once again, we'll be part of one giant supercontinent, Pangea Ultima.

North America, today, is just the middle of this continent's long and interesting story, and it will go on for tens of millions and hundreds of millions of years into the future, because in geology, one thing is for sure: no landscape is permanent.