

## WAX MODEL

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I just wanted to review real quick the reasons why we believe continental drift actually happens. Does anybody want to, maybe, give me a couple answers of why-- or evidence of how we know we that at one point the continents were together, but eventually they did drift apart?

Fossil evidence.

Fossil evidence. So very true. So you have creatures that are organisms, that are kind of roaming across these lands and all over the various continents. But when the continents are separated, obviously, the animals have much harder time migrating from South America to Africa. That doesn't really happen.

But we find fossils about 180 years or 200 million years ago, and these fossils are identical. Some present in Africa, some in South America, or there's similarities between fossils found in India and Africa, and that's led us to believe that the continents were at one point all one super continent. And that's called Pangaea. You guys know that.

So there's glacial evidence. Very good. So we know that just from various fossils, and stuff like that, and also sediment kind of deposits that there are extensive glaciers all around kind of Southern Australia and the southern tip of India, Africa, South America, and Antarctica-- was glaciated at this point. Very good.

So this is actually a geological map of the basement rock. You guys can kind of see some similarities with these kind of pink rocks. And we have some more some similarities, kind of a little bit of a green zone. So we know that basement rock. When we take cores of sediment on land, we get through all of the sediment that's been deposited in recent years. And we reach the basement rock, which was at one point at the surface about 200 million years ago. And we notice that a lot of these basement rocks are very similar.

You guys know the three main plate boundaries? Divergent-- that's the divergent-- and the convergent, and there's also a transform fault. So we see divergent plate boundaries in the middle of the Atlantic, where we have a process called seafloor spreading. And that's what we're going to simulate with the wax model today.

And this is also a great example of how backlighting, once again, gives a much more resolution, in terms of the texture of the wax and the pattern of seafloor spreading geometry. What do you guys see with your eyes that's a little bit different between the two different oceans?

The size of the striations or whatever they're talking about?

Yeah. So these are a bunch of transform faults, what you guys told me is plate boundary before. And you can see in here as well. So you see a lot of transform faults along this ridge in the Atlantic. You see a lot less on the one in the Pacific.

So is that we're seeing here right in the middle of the--

Right. So in the middle here, you guys have these different spreading centers. So this you kind of think of as the Atlantic. And since we have a very kind of slow spreading rate right now, you can understand why there's so many transform faults along here. So what do you guys think will happen if I increase the speed of the motor going that way? Do you guys think it'll be more transform faults or of less transform faults?

Less.

Less. Exactly. So increase, and we should start to see this kind of even out like we see in the Pacific. And you can kind of see all the different spreading centers, which are the dark lines. And they should start forming into bigger transform faults, and that has to do with the spreading rate.

And that's why in the Pacific Ocean, we see so many less transform faults. But one thing you guys will notice is these transform faults aren't completely straight. They kind of look like they curve a little bit. So that allows us to look back in time and calculate the various spreading rates. And also, where these plates are moving, because they're not just spreading apart, they're also going in directions.

So what we can do is we can turn on this motor, and you guys should see that these transform faults begin to bend a little bit. So you guys can see all these big spreading centers right here. This is a pretty big one.

I see how the is straight across.

Yes. So I try to sometimes sprinkle in a little bit of--

So that's [? long lasting, ?] like the map?

What? The table?

I mean, obviously, not that map, but the transform faults on that literally look exactly like the wax model.

Do you guys see the transform fault?

So that's kind of what it's meant to do. It's not the best at simulating the geology and thickness of the various plates, but it's pretty good at simulating the spreading access and all these little transform faults that we see.

In the book, we read that the sediments on the Earth can be like three billion years old, but the sediment in the oceans is only 180 millions years old. Why would that be?

Right. So you guys learned in class that continents are almost-- you thought of ice cubes floating on top of the asthenosphere. And you guys also know that convergent plate boundaries, we have a recycling of oceanic crust, like Matt said in class. And that kind of explains why our ocean basins are so much younger than our land masses, because of this recycling affect.

A lot of places around the Ring of Fire in the Western Pacific that you have the crust being subducting under the continental crust or another oceanic plate, and it slowly begins to melt.

So would that be happening on other side of the--

Right. So we can't exactly model subduction zones in this lab. This is really just meant for divergent plate boundaries and modeling seafloor spreading. It's hard to see on these maps, but the map outside, you guys, you'll notice in India, it's all these kind of pushed up wrinkles right around, where India crashed into Asia. And that happened very recently. That's why the Himalayas are so tall compared to the Appalachian Mountains.

They were once believed to be as tall as the Himalayas. So that's almost 9,000 meters, and they're only about 2000 meters now. And that's just due to millions of years of erosion from rain and changes in temperature, from winter to summer, slowly eroding the rock away.

So what I was about to tell you guys is a student actually used this for-- I believe, it was for her master's thesis. So she would do all this, let it dry, and then she'd put a piece of paper on it and sketch over it with crayons or whatever kind of tool she had. The very cool things that she was doing-- well, she used the other motor so she could put two different paddles on at the same time and kind of simulate how the plates, actually, moved. Because normally, we're not going to have a plate just kind of moving away from the other plate. It's going to be, like I said, going in all different kinds of sorts of directions. They're not just moving away from each other. They're turning a little bit and kind of going all over the place.

So she tried to model, actually, India crashing into Asia. I think the process begin 60 million years ago, but that's what she did, and it was very cool.

How many years would that have been?

This? So great question. So it'll be a little different if you're in the Atlantic or if you're in the Pacific. I normally use the analogy, and I think that that's kind of true. The Pacific plates move apart about as

fast as your fingernails grow. You can't see your fingernail growing, but eventually your fingernail gets long enough, and you to cut it.

So we know that the plates move about that rate, but the Atlantic moves a lot slower. This process right here, if you're kind of considering that this is South America and that side this is Africa, I would say that's about 130 million years. But it's really tough to pinpoint exactly when the continents drifted apart, when they broke apart, when the seafloor spreading axis, actually, formed and started producing new oceanic crust, but very good question.

What follows in the remaining four minutes of this video is another seafloor spreading example in the wax model that was presented by Naar and others at the 1991 fall American Geophysical Union Meeting.

The pattern we see below is a pattern of a seafloor spreading the black lines that run up and down the page, and the thin slits that cut across, left to right, are transform faults. On the very far left, under the thick piece of wax, is a black liquid lava wax, which simulates a hotspot. The geometry designed here is to simulate what we think may have happened along the East Pacific Rise, near Easter Island, which is thought to have been a hotspot.

This is a model that was proposed by Hay and others in 1985 in a nature paper. And what we see here is the wax plate on the right is stationary to the tank. and the wax played on the left is moving towards a hotspot. That elongated liquid black feature in the wax is to simulate a hotspot chain of volcanoes. Unfortunately, it's so hot the volcanoes don't form or freeze, but the overall geometry is similar to what we think happened in the South Pacific.

Now you can see some parallel lines, which would look like isochrons on a magnetic anomaly map. These features are forming, because the rate change occurred in the wax as we are adjusting controls. The lighting is from far away. So it's reflecting off the wax. And the liquid wax reflects the light differently than the solid wax.

As the wax gets older, it gets thicker, much like we think the ocean lithosphere does. Oldenburg and Brune in the 1970s made a simpler version of this model. And this is more refined hybrid of that model that was made at the University of South Florida in the early 1990s.

Now as a spreading ridge down below starts approaching the hotspot, we're going to see some changes. What we're going to see is that a new spreading ridge is going to initiate near the hotspot and crack down the page. If we were looking from the north, it would be propagating towards us, in the way we think the Easter microplate may have formed.

So watch carefully, the ridge on the right side slowed down and stretched and a new one cracked down the page. This is what we think may have formed the Easter microplate and gives us a good example of ridges, transform faults, and hot spots.

The old ridge has turned off, and the new ridge has now become dominant. This example is a simple example of a ridge or I should say seafloor spreading segment, offset by a transform fault, to another seafloor spreading segment. The transform fault is where the two plates are sliding by each other, and the spreading segments are the thin black lines where liquid wax is rising and freezing to the trailing edge of the wax plates.

The trace of the transform fault, or what we call a fracture zone, extend the left and to the right of those spreading segments. And as you can see, the plate on the left is fixed. And the one on the right is moving to the right. And across that transform fault, you can see differential motion. And so the plates keep growing with the youngest part of the wax plate near the spreading center, and the oldest plate where the initial cut was made.