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A history of supercontinents on planet Earth

Earth's continents are constantly changing, moving and rearranging themselves over millions of years - affecting Earth's climate and biology. Every few hundred million years, the continents combine to create massive, world-spanning supercontinents. Here's the past and future of Earth's supercontinents.

The Basics of Plate Tectonics

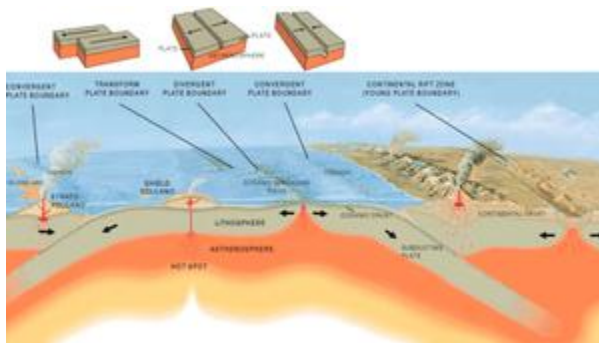
If we're going to discuss past and future supercontinents, we first need to understand how landmasses can move around and the continents can take on new configurations. Let's start with the basics - rocky planets like Earth have five interior levels: heading outwards, these are the inner core, outer core, mantle, upper mantle, and the crust.

The crust and the part of the upper mantle form the lithosphere, a portion of our planet that is basically rigid, solid rock and runs to about 100 kilometers below the planet's surface. Below that is the asthenosphere, which is hot enough that its rocks are more flexible and ductile than those above it. The lithosphere is divided into roughly two dozen major and minor plates, and these plates move very slowly over the almost fluid-like asthenosphere.

There are two types of crust: oceanic crust and continental crust. Predictably enough, oceanic crust makes up the ocean beds and are much thinner than their continental counterparts. Plates can be made up of either oceanic or continental crust, or just as often some combination of the two. There are a variety of forces pushing and pulling the plates in various directions, and indeed that's what keeps Earth's crust from being one solid landmass - the interaction of lithosphere and asthenosphere keeps tearing landmasses apart, albeit very, very slowly.

When Plates Meet

The diagram below gives you a good idea of the different ways that plates can interact at the boundaries between them. There are convergent boundaries, in which two plates smash into each other. Two possible things can happen here - either one plate slips underneath the other and is subsumed and destroyed in the furnace of Earth's mantle, or the two plates collide and force up huge mountain ranges. These collisions are also often responsible for volcanism.



There can also be transform boundaries, where the two plates move in parallel, glancing off of each other with not much more than some scrapes. Of course, those scrapes become something much more severe when translated to human terms - one of the most famous examples of a transform boundary is California's San Andreas fault, responsible for some of the most devastating earthquakes in American history.

Finally, there are divergent boundaries, in which two plates slide away from each other. These are far more mild in their effects, and such boundaries have created places like Africa's Great Rift Valley and various giant ocean ridges like the Mid-Atlantic Ridge.

It's absolutely crucial to remember that all of this happens incredibly slowly, and that it takes many millions of years for any effects to be actually observable. At their absolute quickest, plates only move about 160 millimeters per year, and most only go about 10 to 40 millimeters per year. To get some idea of how slow that really is, let your hair and fingernails grow uncut for an entire year. Your fingernail growth represents the slower pace of plate movement, while your hair growth is the same as the absolute greatest distance any plate has traveled in the last year.

Defining a Supercontinent

There are only so many directions in which the various plates can move, and it's only a matter of time before the continents smash together to form a single supercontinent. Right now, we're probably a little past halfway through the current supercontinent cycle, with the last supercontinent Pangaea having formed about 300 million years ago and the next supercontinent due in (very) roughly 250 million years.

We need to be careful with our terminology here. Continent itself isn't a well-defined term - just look at how nobody knows whether the continent in the south Pacific Ocean should be called Australia or Oceania

to see how tricky these things are to define - and the term supercontinent can be applied to any unusually large landmass.

Indeed, the landmass consisting of Europe, Asia, and Africa is definitely a supercontinent, the Americas arguably count as well, and we're one submerged land bridge in the Bering Strait away from linking up all five anyway. So, for the sake of simplicity, we'll restrict the term "supercontinent" to only those that pretty much comprised all the landmasses on Earth at a given period.

The Current Cycle

The most recent supercontinent, and the only one most people are familiar with, is Pangaea, which dominated Earth from about 300 to 150 million years ago. There are a few ways we know of its existence. There's the fact that species from this time showed relatively little diversity, no matter how far apart they were geographically, which indicates they weren't isolated from one another by oceans.

The geology of various modern continents also indicate how they used to be connected to each other. You only have to glance at a map to see how eastern South America and western Africa fit rather neatly together, and geological research has revealed these areas still share some key features that prove their one-time connection.

Pangaea gets remembered because it's the most recent supercontinent, and because its later days overlap with the birth of the dinosaurs in the late Triassic and early Jurassic. Geologically speaking, it's easy to look at Pangaea as a counterpart of sorts to the seven continents we live on today, with the twin giant continents of Gondwanaland and Laurasia as a transitional stage between these two extremes. But it's generally forgotten that Pangaea is just the latest in a line of about half a dozen supercontinents, and Earth will see quite a few more over its final five billion years of life.

Back To The Beginning: Ur and Valbaara

Earth's earliest days remain somewhat mysterious - indeed, much of what we're discussing here is still being worked out by geologists, and so we have to make a lot of best guesses in tackling these topics. A complete accounting of how our planet formed from clumps of space rock into something even theoretically capable of supporting life is really worth its own separate post. For our purposes, we can start around four billion years ago, when Earth's oceans were already in place and the first protocontinents began to form. During this period, plate building blocks known as cratons, which are essentially giant rock cores, started to come together and rise to the surface.



There are a couple candidates for the very first continents. There's some evidence that two cratons date back to as much as 3.5 billion years ago, forming the tiny continent of Vaalbara. It's a supercontinent simply because it was all alone on our planet - any explorers visiting Earth would have seen a single brownish dot against all the blue. Today, Vaalbara is spread between two cratons - the Kaapvaal craton in

southern Africa and the Pilbara craton in northwestern Australia. We suspect Vaalbara's existence because rocks ejected from these cratons are some of the oldest in the world, and there are a number of geological clues that the two cratons were once together.

Still, Vaalbara's existence is still rather speculative, and so the more certain candidate for oldest supercontinent is Ur. Like its possible predecessor, Ur was smaller than any of today's continents, but it may well have spent many millions of years as the only continent on our planet, with nothing but some tiny islands to keep it company. Today, Ur lives on as part of India, Madagascar, and Australia.

While Vaalbara likely existed from about 3.6 to 2.8 billion years ago, at which point its cratons were broken apart, Ur formed roughly 3 billion years ago and actually survived in tact as part of larger supercontinents until the break-up of Pangaea only 200 million years ago. At just under 3 billion years, Ur is almost certainly the longest-lived landmass this planet will ever see, and yet now it remains hopelessly obscure.

Kenorland and the first Snowball Earth

Of course, continents that were just half the size of Australia can't really be considered supercontinents by today's standards, but that was the world in which they existed. The planet was almost entirely ocean at this phase in its history, and cratons weren't pushed up from the mantle all at once. We start to get a little closer with the emergence of Kenorland and Columbia, the next two supercontinents.

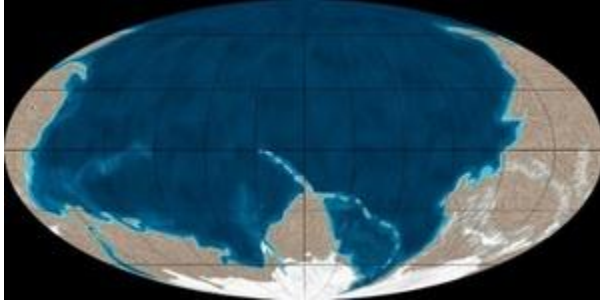
Kenorland formed roughly 2.7 billion years ago, and it was considerably larger than Ur or Vaalbara, although still not gigantic. It comprised most of the modern US and Canada, Greenland, the Scandinavian countries, western Australia, and what is now the Kalahari Desert, which stretches over much of southern Africa. Kenorland likely existed around the equator, and probably had about a hundred million years as the Earth's dominant landmass.

Geologists are still working out the complete story of Kenorland, but it appears that the supercontinent broke up around 2.6 billion years ago, creating a massive spike in rainfall. This in turn caused a decrease of greenhouse gases like carbon dioxide, which wasn't helped by the fact that the Sun itself was weaker then it is now, at only about 85% its present power. This created the first Snowball Earth, as the entire planet spent millions of years at below freezing temperatures. It wouldn't be the last time a breakup of a supercontinent wreaked massive environmental consequences.

Columbia, Rodinia and Panottia

The first "proper" supercontinent was probably Columbia, which formed around 1.8 billion years ago. Columbia had a land mass of roughly 50 million square kilometers - still quite a bit less than our modern total of about 150 million, but still pretty immense. From this point on, the picture starts to get *a lot* clearer, as we reach the first supercontinent that geologists are absolutely certain about.

Rodinia formed about a billion years ago out of the long-dispersed remnants of Columbia, along with additional cratons and pieces of crust that had risen up in the hundreds of millions of years. We don't know a lot about exactly what Rodinia looked like, but it was big, was probably located almost entirely south of the equator, and began to break apart roughly 550 million years ago.



(Rodinia Supercontinent)

This breakup was one of the most important and cataclysmic events in our planet's history. Like the breakup of Kenorland, Rodinia's destruction created a Snowball Earth, but that wasn't all. Rodinia, like all the supercontinents before it, had been completely devoid of life, as all organisms still lived in the oceans. The breakup of Rodinia opened up new oceans and caused the sea beds to rise, creating shallower seas that offered the much-needed stepping stone for animals and plants to make their way onto land.

There were also more subtle effects. The breakup of Rodinia created massive volcanic explosions, which likely shot rich nutrients from beneath the Earth into the oceans. This made life considerably easier for organisms, first helping them weather the extremes of the Snowball Earth and then giving them the energy boost needed to colonize land. Without Rodinia, and certainly without plate tectonics, none of us would be here today.

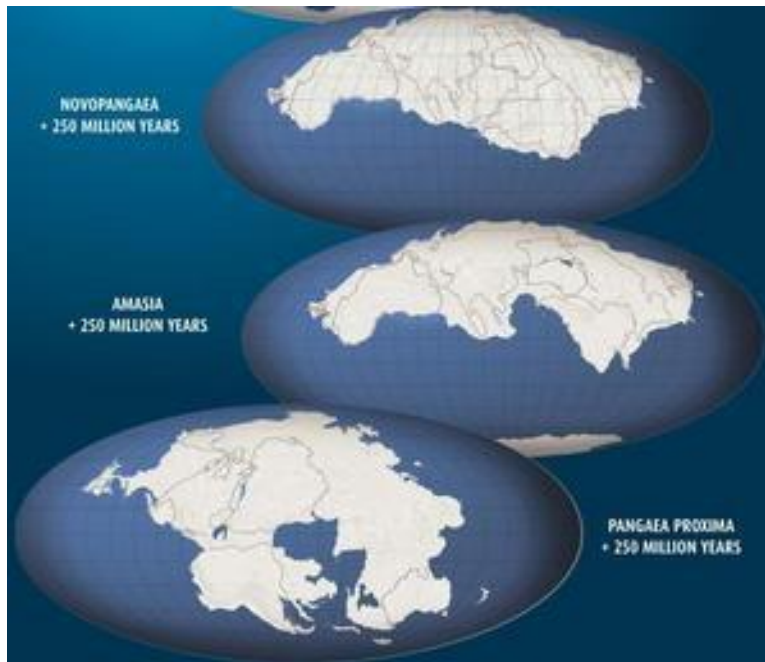
Three Possible Futures

Between Rodinia and Pangaea, there may have been one other supercontinent, which is known as Pannotia. Assuming it existed - and there's still disagreement on that point - Pannotia was something of an accidental supercontinent, created by glancing collisions between tectonic plates instead of any real couplings. The Pannotia supercontinent configuration was one born of coincidence and didn't last long, breaking up just 60 million years later and giving way to Pangaea, last of Earth's supercontinents.

For the time being, at least. Continents are still on the move, and they'll almost certainly continue to move until the Sun vaporizes our planet in five billion years' time. In all likelihood, the continents will merge again to form a new supercontinent within the next 250 million years, completing the latest turn of the supercontinent cycle.

The most preferred theory predicts the following scenario. Enjoy the Atlantic Ocean while you can, because it won't be around forever. Africa and North America will crash into each other, while South America is going to get cozy with Antarctica. Australia will crash into China and southeast Asia, which really just sounds like the premise for a mildly offensive sit-com. And Europe? Poor Europe looks like it's headed for significantly colder climes, getting dangerously close to becoming the new North Pole.

This is however, just one potential configuration, although there are at least three scenarios that geologists consider realistic. All of them have pretty awesome names: Novopangaea, Amasia, and my personal favorite, Pangaea Ultima. The version we see above, with the closure of the Atlantic, is Pangaea Ultima, whereas the Novopangaea and Amasia model holds that it's the *Pacific* that will close, making the Atlantic far bigger than any of today's oceans. Here are some artist's conceptions of all three:



Pangaea Ultima is probably the somewhat preferred theory of geologists, but there the Pacific plate *does* seem to be sliding underneath North America and Eurasia, which would mean the ocean itself will close if it continues on this present course. But that's the problem - we're trying to predict millions of years worth of incremental movement based on a pitifully incomplete dataset. A best guess is about the most we can really expect.

The Ever-Changing World

Plate tectonics has driven the story of our planet. When all the continents were one, organisms moved freely and spread out across the planet - dinosaurs might not have become the dominant species if they hadn't had Pangaea to give them absolute control of all land. When the continents dispersed, the isolation of different populations caused a spike in genetic diversity that drove crucial periods of evolution. It's unlikely that humanity could have ever made it if our ancestors (and I'm going back to our pre-primate ancestors here) had lived exclusively on a supercontinent or isolated landmasses.

And, of course, climate is shaped by the Earth's shifting geology. Twice supercontinents have split apart to create devastating chain reactions resulting in the Snowball Earth. Continents opening up and coming together has both cooled and warmed the planet in complex interactions that we're still puzzling over. Indeed, the saga of the supercontinents is still incomplete, and not just because we don't know where it's headed. There's a lot about our own past that we still have to work out.

But we already probably know the coolest part about plate tectonics - it's the idea that the past and future of our planet don't necessarily look anything like the Earth we live on right now. If you got in a time machine and headed 250 million years in either direction, you'd think you were looking at an alien planet, and our world is only going to look stranger and more unrecognizable the further into the past and future we go. So here's to the Pangaeas, both Classic and Ultima, the once and future supercontinents.

For more on this topic, check out [Plate Tectonics: An Insider's History of the Modern Theory of the Earth](#) by Naomi Oreskes and [Supercontinent: Ten Billion Years in the Life of Our Planet](#) by Ted Nield.